VEGETABLE GARDENING IN THE TROPICS

Circular No. 32

Federal Experiment Station in Puerto Rico

UNITED STATES DEPARTMENT OF AGRICULTURE

Office of Experiment Stations

FEDERAL EXPERIMENT STATION IN PUERTO RICO

MAYAGUEZ, PUERTO RICO

Administered by the Office of Experiment Stations
Agricultural Research Administration
United States Department of Agriculture

R. W. TRULLINGER, *Chief, Office of Experiment Stations*

STATION STAFF

KENNETH A. BARTLETT, *Director.*
ARNAUD J. LOUSTALOT, *Assistant Director and Plant Physiologist.*
CALEB PAGÁN CARLO, *Chemist.*
HAROLD K. PLANK, *Entomologist.*
HAROLD F. WINTERS, *Horticulturist.*
HARRY E. WARMKE, *Plant Geneticist.*
THOMAS THEIS, *Plant Pathologist.*
RICHARD H. HAGEMAN, *Plant Physiologist.*
THOMAS J. MUZIK, *Plant Physiologist.*
HÉCTOR J. CRUZADO, *Scientific Aid.*
RUBÉN H. FREYRE, *Scientific Aid.*
CARMELO ALEMAR, *Administrative Assistant.*
NARCISO ALMEYDA, *Collaborating Agronomist.* [1]
FÉLIX A. JIMÉNEZ TORRES, *Collaborating Agronomist.* [1]
EUGENIO CABANILLAS, *Collaborating Agronomist.* [1]
FILIBERTO MONTALVO DURAND, *Collaborating Agronomist.* [1]
ELIDA VIVAS-RUIZ, *Collaborating Botanical Assistant.*
JEAN GARCÍA RIVERA, *Collaborating Chemist.* [1]
ASTOR GONZÁLEZ, *Collaborating Librarian.* [1]

---

[1] In cooperation with the Government of Puerto Rico.

COVER ILLUSTRATION.—Home vegetable gardens are an excellent source of vitamins and minerals for health. A regular program of planting backyard gardens should be taught and encouraged by vocational agriculture classes, 4–H Club project committees, and similar organizations.

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. — Price 40 cents

CONTENTS

ACKNOWLEDGMENTS

In the preparation of this circular the authors sincerely appreciate the help and suggestions of the following individuals: Arturo Riollano, agronomist, Puerto Rico Agricultural Experiment Station, Isabela; Pedro Osuna, Puerto Rico Agricultural Extension Service (Río Piedras); Victor R. Boswell, S. P. Doolittle, and W. H. White of the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture; Prof. C. H. Nissley, New Jersey Agricultural Experiment Station; Rafael Charneco, manager, Puerto Rico Agricultural Company Farm, Bayamón; Lt. Albert Gehres, garden supt., United States Army Air Base, Borinquen Field; Juan Adrover, grower, Yauco; Robert W. Claiborne, grower, Maricao; and numerous other local growers whose gardens were visited. Héctor R. Cibes, formerly collaborating agronomist, Federal Experiment Station, assisted with several photographs and charts, and Astor González, librarian, gave library assistance. Dr. G. N. Wolcott, entomologist, Puerto Rico Agricultural Experiment Station (Río Piedras), and Dr. J. A. B. Nolla, plant pathologist, Central Igualdad, Mayagüez, checked and made suggestions, respectively, for the sections on insects and diseases and their control.

FEDERAL EXPERIMENT STATION IN PUERTO RICO

of the

United States Department of Agriculture

MAYAGUEZ, PUERTO RICO

Circular No. 32

WASHINGTON, D. C. OCTOBER, 1950

VEGETABLE GARDENING IN THE TROPICS[1]

By Norman F. Childers, *formerly assistant director and plant physiologist*;[2] Harold F. Winters, *horticulturist*; Pedro Seguinot Robles, *formerly collaborating agronomist*; and Harold K. Plank, *entomologist*.

INTRODUCTION

Almost any vegetable that can be grown in the Temperate Zone can be grown in the Tropics, provided the proper variety, season, altitude, and soil conditions are selected. There is no frost hazard in the Tropics except at very high altitudes, and in many areas there is a 12-month growing season with abundant sunshine almost every day. Insects and diseases may be factors, but under average conditions they appear to be no more troublesome than in the Temperate Zones. The year-round activity of toads, lizards, and many other predators seems to counteract more or less the lack of control of insects by freezing weather. Diseases may be of only minor concern where rainfall is light and well distributed through the year.

That many vegetables are well adapted to the Tropics is not surprising, as a large number are native to the Tropical Zone. Vegetables of apparently tropical origin are the tomato, sweetpotato, lima bean, pepper, potato, cowpea, eggplant, chayote, corn, and possibly the common bean, soybean, okra, and muskmelon. Native varieties of some of these vegetables still grow wild in the Tropics. Actually, many of the present varieties of these vegetables have been acclimated to temperate conditions by a program of selection and controlled breeding and, therefore, may not be so well adapted to their native areas. Thus, it is important to use only those varieties that have proved most productive under tropical conditions.

[1] This is a complete revision of and supersedes the bulletin, "Vegetable Growing in Puerto Rico," by H. C. Hendricksen, Puerto Rico (Mayagüez) Agr. Expt. Sta. Bul. No. 7, 58 pp. 1906.

[2] Now, chairman, Department of Horticulture, Rutgers University, New Brunswick, N. J.

During World War II there was a heavy demand for fresh vegetables by servicemen stationed at tropical bases. Few, if any, of the vegetables they were accustomed to were available from the surrounding areas. Furthermore, shipment of refrigerated fresh vegetables from the United States was costly and often prohibitive because of lack of shipping space. Several successful gardens were established and maintained on these bases, but the supervisors reported many crop failures caused largely by improper selection of kinds and varieties for the prevailing soil and climatic conditions.

This circular has been prepared partly to meet the need for information on culture and partly to answer inquiries from institutions and individuals in the Tropics. The information and recommendations are based on more than 45 years' experience with vegetables at this station, as well as on the authors' observations in the American Tropics and a review of the literature from other tropical institutions (p. 139). Also between 1945 and 1947 the authors conducted a series of intensive trials at three altitudes in Puerto Rico—Mayagüez (50 feet), Maricao (2,600 feet), and Toro Negro (3,300 feet) (fig. 1)—to determine the effect of season and altitude (temperature) on production of more than 45 vegetables, from a few to several varieties each. The vegetables were planted at 2-month intervals in 50-foot rows. Half of them were tested the first year and half the next.

The scope of this subject and the area of the world covered are much too broad to be treated adequately in a single publication of this size. Thus, it is suggested that the reader supplement the information presented here with experiences and recommendations of local growers and of the nearest agricultural research or teaching institutions. Their suggestions will be particularly valuable with respect to varieties that are locally desirable and to the best methods for dealing with prevailing insect and disease problems.

NEED FOR VEGETABLES

The diet of people in the Tropics is low in fresh vegetables, particularly the green and leafy types which are valuable for their high vitamin and mineral contents. A survey of diets in Puerto Rico (table 1), which are fairly typical of those in most tropical areas, showed an unbalanced condition; consumption of leafy and green vegetables was only about half of that needed for an adequate diet while consumption of starchy and protein vegetables was more than adequate (*31*).[3] Apparently, then, vegetable gardening should be expanded in the Tropics, with particular emphasis on the green and leafy types.

Vegetables especially high in minerals and vitamins include broccoli, lettuce, mustard, parsley, carrot, turnip tops, cowpea, collard, sweetpotato, tomato, and most kinds of beans (*13, pp. 103–104*). Vegetables moderately high in these constituents are beet tops, head cabbage, Chinese cabbage, celery, chard, bunching onion, spinach, peas, corn, potato, and eggplant. Vegetables of relatively low nutritive value include beet root, radish, turnip, chayote, okra, cucumber, and melons.

[3] Italic numbers in parentheses refer to Literature Cited, p. 139.

FIGURE 1.—Trial gardens at (*A*) Maricao, (*B*) Toro Negro, and (*C*) Mayagüez, where observations and data were collected on the effect of altitude on growth and production of different vegetables under tropical conditions.

CLIMATIC RELATIONSHIPS

TEMPERATURE.—Variations of 3° to 5° F. in mean temperature from one location to another have a marked effect on the success with which different kinds and varieties of vegetables can be grown in the Tropics. For example, on the island of Puerto Rico there is about a 5° difference in mean temperature between the warmest period of the year, in August, and the coolest, in January or February (fig. 2). The mean temperature for any month at sea level as compared with that at higher altitudes, however, may differ as much as 5° to 10° or more, a condition that is typical of many places in the Tropics (*13, pp. 104–106*). Thus (table 2 and fig. 3), the August mean temperature at Toro Negro may be 10° to 11° lower than at Mayagüez at sea level. The effect of elevation and temperature on the Melting Sugar pea grown simultaneously at Mayagüez, Maricao, and Toro Negro is shown in figure 4.

Generally speaking, temperature is closely correlated with altitude, although at a given altitude one location may be cooler than another, depending upon rainfall, cloudiness and prevailing breezes. For ex-

TABLE 1.—*Food supply of Puerto Rico in 1944–45 compared with needs for an adequate diet at minimum cost*[1]

Food group	Food Supply							
	Per capita consumption[2]	Adequate diet at minimum cost[3]	Percent amount consumed is of adequate diet	Amount needed to cover total deficiency	Total deficiency or excess in terms of local supply	Deficiency or excess per capita		
						1930–40	1944–45	1960[4]
	Pounds	*Pounds*	*Percent*	*1,000 lbs.*	*1,000 lbs.*	*Pounds*	*Pounds*	*Pounds*
Cereals and preparations	210.9	224.0	94.2	−26,593	−427,283	−13.2	−13.1	−202.5
Starchy vegetables	249.4	165.0	151.2	+171,332	+115,818	+186.0	+84.4	+197.0
Green and leafy vegetables	39.5	80.0	49.4	−82,215	−99,674	−33.5	−40.5	−3.6
Protein vegetables (beans and peas)	49.4	30.0	164.7	+39,382	−26,225	+16.5	+19.4	+10.6
Fruits and preparations	112.3	50.0	224.6	+126,469	+108,738	+60.3	+62.3	+51.8
Milk and equivalents	211.5	572.0	37.0	−731,815	−946,160	−431.9	−360.5	−296.5
Oils and fats	17.6	49.0	35.9	−63,742	−99,470	−15.9	−31.4	----------
Lean meats and fish	33.1	60.0	55.2	−54,607	−71,966	−5.1	−26.9	−8.5
Eggs	4.7	21.0	22.4	−33,089	−33,887	−16.4	−16.3	−16.1
Sugar	84.8	35.0	242.3	+101,094	+136,950	+42.5	+49.8	----------

[1] Adapted from mimeographed tables issued by R. Colón Torres, Dept. Agr. Econ., P. R. Agr. Expt. Sta., Río Piedras. 1945.

[2] Based on estimated population of 2,030,000 as of January 1, 1945.

[3] Stiebeling, H. K., and Ward, M. M., "Diets at Four Levels of Nutritive Content and Cost," U. S. Dept. Agr. Cir. 296. 59 pp., illus. 1933.

[4] Estimated on basis of a population of 2½ million people.

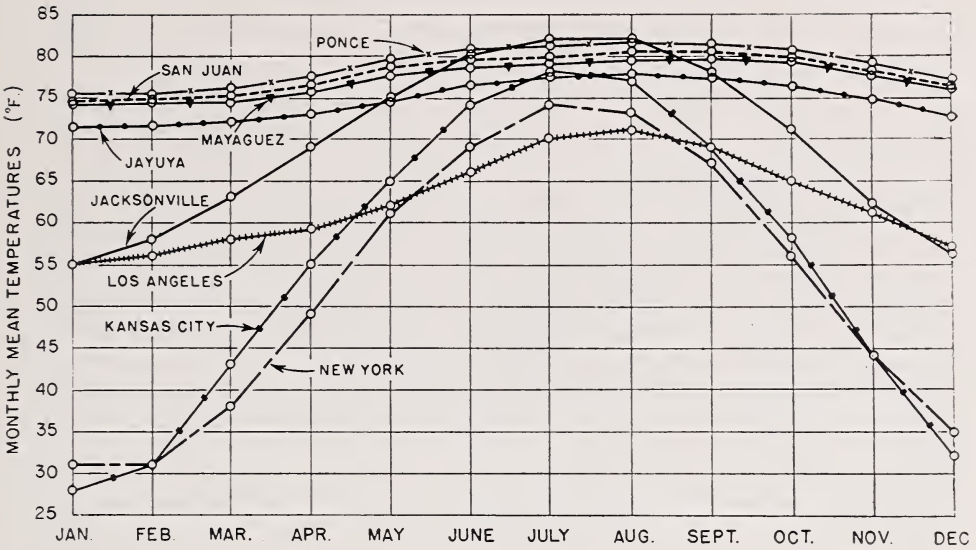


FIGURE 2.—Temperature difference between summer and winter in the Tropics may be only 5° to 10° F., whereas in the Temperate Zone it may be more than 50°. Temperature variation of only a few degrees, however, is an important factor in vegetable production in the Tropics. (These comparisons are between cities in Puerto Rico and the continental United States.)

ample, mainly because of low rainfall, Ponce, P. R., at sea level has about a 4° or 5° F. higher mean temperature than Río Piedras also near sea level. Ponce receives about 36 inches of rainfall annually as compared with 73 inches for Río Piedras.

At or near the Equator, where the mean temperature is almost the same for all months, vegetables are grown at different altitudes in accordance with their temperature requirements. Thus, eggplant being transported to markets up the mountain often passes cabbage being sent to markets down the mountain. In fact, the same exchange of cool- and warm-season crops between high and low altitudes occurs in most sections of the Tropics, but season also plays an important part in the availability of different vegetables in the upper and lower latitudes of the Tropics.

HUMIDITY AND RAINFALL.—In many tropical regions heavy rainfall is probably the most important limiting factor in vegetable growing for several months of the year, particularly where the soil is heavy, drainage is slow, and rainfall may total 10 to 20 inches in a week or two. Heavy rainfall may severely stunt and kill vigorous fruiting tomato plants within a week. Thus, the 22.78 inch rainfall recorded in May 1945 at Maricao (fig. 3) almost destroyed the vegetable planting despite the fact that the Nipe[4] soil there has reasonably good drainage. That heavy rainfall, with the accompanying excess soil moisture and diseases, is disastrous in summer production of tomatoes was clearly demonstrated in 1947 at Mayagüez (*35, 1947*).[5] Excellent crops of tomatoes were grown in both soil and gravel culture under greenhouse

[4] See Roberts et al. (*41*) for description of Nipe clay soil on which the Maricao garden was located, the Toa loam at Mayagüez, and the Cialitos clay at Toro Negro.

[5] See also section on gravel culture method of growing vegetables.

TABLE 2.—*Maximum, minimum, and mean temperatures at Mayagüez (50 feet), Maricao (2,600 feet), and Toro Negro (3,300 feet) in Puerto Rico, recorded near areas where vegetable trials were made*

Month	Temperature														
	Extreme maximum at—			Mean maximum at—			Mean at—			Mean minimum at—			Extreme minimum at—		
	Maya.	Mari.	T.N.	Maya.	Mari.	T.N.	Maya.	Mari.	T.N.	Maya.	Mari.	T.N.	Maya.	Mari.	T.N.
1945	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
June	93.0	------	80.7	89.1	------	76.1	73.6	------	6.77	68.0	------	59.3	65.0	------	56.1
July	92.0	------	82.0	89.0	------	75.0	79.1	------	6.77	69.1	------	60.4	67.0	------	53.0
August	92.0	------	79.9	89.4	------	74.4	78.8	------	67.6	68.1	------	60.9	65.0	------	57.0
September	93.0	81.8	80.9	86.3	77.4	75.5	78.0	71.3	68.8	69.7	65.2	62.1	67.0	61.8	56.3
October	93.0	79.9	83.0	89.8	76.8	77.1	79.1	69.9	70.4	68.4	63.0	63.7	65.0	60.2	60.1
November	91.0	78.9	81.0	87.1	74.7	75.0	76.6	67.4	68.5	66.0	60.1	62.0	60.0	54.6	54.0
December	90.0	79.2	79.9	86.9	74.2	75.2	76.0	66.6	68.0	65.1	59.0	60.9	62.0	55.0	55.9
1946															
January	89.0	78.2	78.0	85.4	73.4	73.5	75.2	65.7	67.3	65.0	58.0	61.1	62.0	55.0	56.1
February	89.0	77.8	77.2	85.5	71.5	71.0	74.0	63.6	64 9	62.6	55.8	58.8	60.0	53.0	51.6
March	91.0	79.2	75.2	86 3	74.2	70.4	74.7	65.8	63.4	63.0	57.4	56.4	59.0	53.0	51.4
April	90.0	79.0	77.3	87.2	75.6	72.8	75.9	66.8	64.6	64.5	58.0	56.3	62.0	52.3	47.3
May	93.0	81.0	77.1	88.1	77.2	73.3	77.5	69.2	66.6	66.9	61.1	59.9	61.0	56.8	54.0
June	93.0	83.3	81.5	89.5	78.7	75.5	78.7	70.8	68.4	67.9	62.9	61.4	65.0	60.7	58.0
July	95.0	84.2	84.0	89.8	79.0	76.8	79.3	70.7	69.0	68.7	62.4	61.3	67.0	58.5	56.8
August	95.0	83.7	80.7	90.9	79.3	76.4	80.0	70.8	69.3	69.0	62.4	62.2	66.0	58.7	56.8
September	93.0	82.0	79.8	90.4	77.6	74.9	79.4	70.1	68.0	68.3	62 6	61.0	66.0	58.9	57.0
October	93.0	82.0	78.3	88.3	77.4	72.9	79.0	70.0	66.8	69.6	62.6	60.8	68.0	60.6	57.9
November	91.0	85.7	76.2	86.4	76.0	71.9	77.2	69.6	65.8	68.0	63.3	59.8	66.0	59.0	54.3
December	90.0	78.0	75.5	86.6	73.2	70.8	76.7	67.0	65.2	65.7	60.8	59.5	60.0	57.5	54.0
1947															
January	89.0	77.0	76.1	85.5	73.5	71.8	74.7	67.0	64.9	63.9	60.4	58.0	61.0	55.0	53.5
February	93.0	81.0	75.5	87.4	74.6	71.6	76.0	67.6	64.4	64.6	60.7	57.2	59.0	55.5	48.7
March	93.0	81.0	77.5	89.3	78.2	74.1	76.8	69.8	65.4	64.2	61.5	56.8	62.0	59.0	51.7

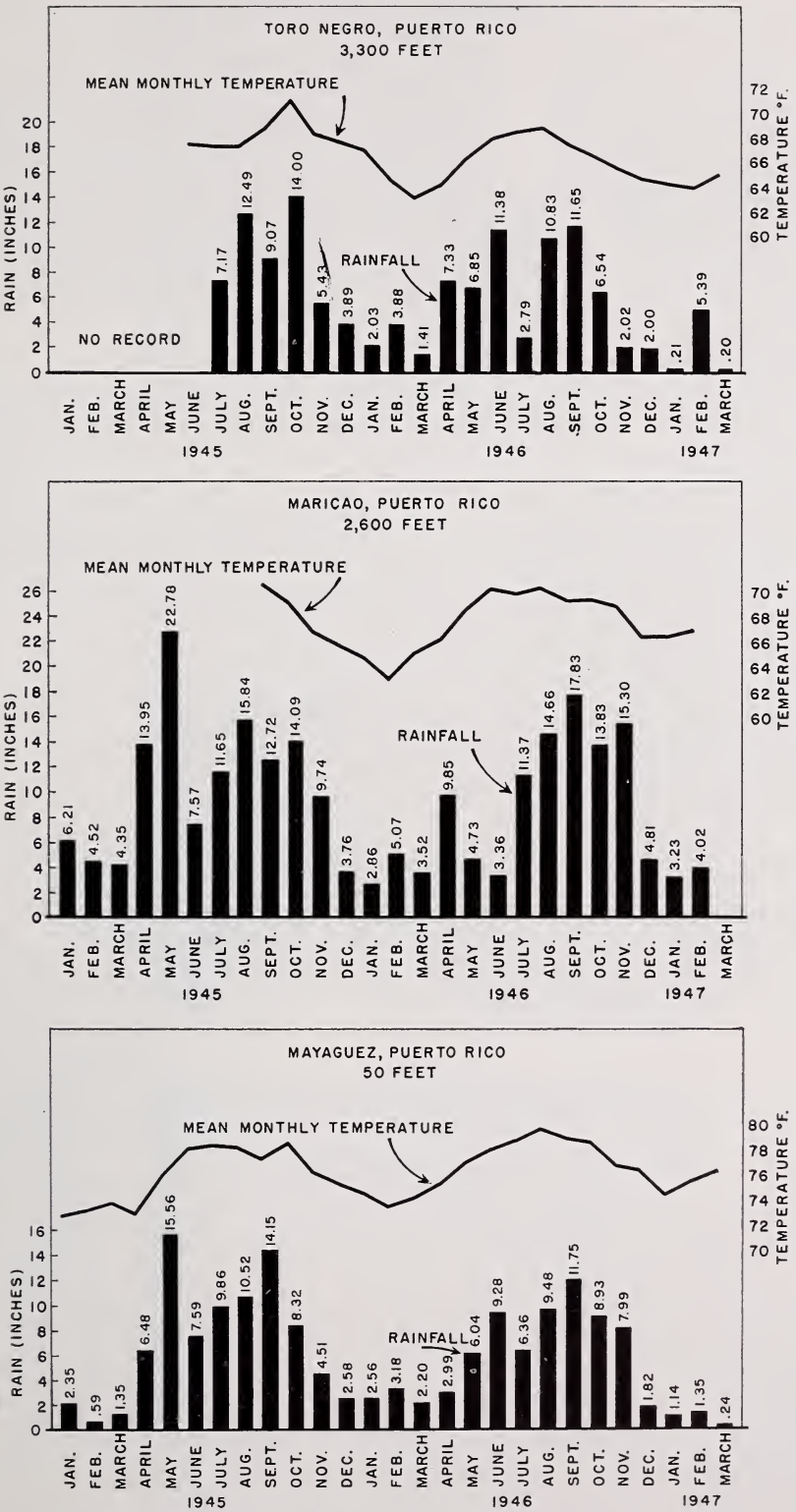


FIGURE 3.—Rainfall and temperature conditions at the three altitudes in Puerto Rico where the 2-year vegetable trials were conducted. Note a 10° to 11° F. annual temperature difference between Mayagüez (50 feet) and Toro Negro (3,300 feet).

FIGURE 4.—Effect of altitude (temperature) on growth of Melting Sugar peas. All peas were planted within approximately the same week at (left to right) Toro Negro (3,300 feet), Maricao (2,600 feet), and Mayagüez (50 feet). Photographs were taken, respectively (left to right), October 18, October 20, and October 23, 1945. Yields were in proportion to vegetative growth. Similar response was obtained with the Telephone variety.

FIGURE 5.—Windbreaks are frequently needed in the Tropics to prevent damage (*A*). A coconut palm-leaf windbreak (*B*) was used at Borinquen Army Air Base, where there is a continuous strong breeze. Pieces of galvanized iron or boards (*C*) were used for protecting cucurbit seedlings at Maricao. The commercial garden (*D*) was protected from prevailing winds by a hill in the background.

protection when only average to poor crops were grown in the field under prevailing rainy conditions.

For the full year of 1946, rainfall at the three altitudes was as follows: Toro Negro, 68.71 inches; Maricao, 107.22 inches; and Mayagüez, 72.58 inches (fig. 3). The garden at Toro Negro received the lowest rainfall and the one at Maricao the highest during the period of the vegetable trials.

WIND.—Continuous winds of 20 to 30 miles an hour may be a limiting factor, particularly with insular climates. Plants in windy areas are retarded or killed by a whipping, twisting action (fig. 5, *A*), and by desiccation during dry periods. Under these conditions it is difficult or impossible to grow vegetables without some provision for windbreaks. (See p.26.)

CLIMATIC REQUIREMENTS OF VEGETABLES.—Figure 6 shows the temperature range over which certain vegetables can be grown most successfully, as well as the temperature range, altitude, and rainfall for several places in the Tropics (*37*). Data for a particular location may be obtained from the nearest weather station. Mean temperatures at low elevations are frequently too high for best performance of some vegetables, such as cabbage, whereas warm-season crops, such as eggplant and okra, are likely to perform better. Although the crops given in figure 6 grow better at the temperatures indicated under average conditions, it may be possible to obtain satisfactory crops outside the specified temperature ranges under special conditions, such as a particularly good growing season, shading with palm leaves, cheese-

cloth or other materials, or with gravel culture. (See Mullison and Mullison in Additional References section, p. 143.)

Several vegetables have been grouped together in figure 6 for practical purposes, despite the fact that all do not have the same optimum temperature range. For some crops, as the garden pea, the optimum temperature range is relatively narrow; for others, such as the cucumber, it is fairly wide. Vegetable plantings in May and June north of the Equator will develop and mature in increasingly warm weather, whereas plantings in October and November will mature in increasingly cool weather. The opposite is true south of the Equator, where the seasons are reversed. Thus above the Equator, cool-season crops, such as cabbage, should succeed well if planted from October to December, inclusive, and warm-season crops, such as okra and eggplant, between March and June. As shown in figure 6, at low elevations a wider variety of vegetables usually can be grown during the cool winter months than during the warm summer season, and at medium to high elevations many vegetables can be grown throughout the year.

Length of day.—Length of day may have a pronounced effect on the vegetative growth, flowering, and tuberization of some vegetables. The difference in day length between summer and winter is less in the Tropics than in the Temperate Zones. In Puerto Rico at 18° N. latitude, days vary from 11:1 hours in January to 13:7 hours in July (fig. 7). At the Equator day and night are about equal in length the year round. Near Washington, D. C., however, at 39° N. latitude in the Temperate Zone, day length is about 9½ hours in December and 15 hours in June.

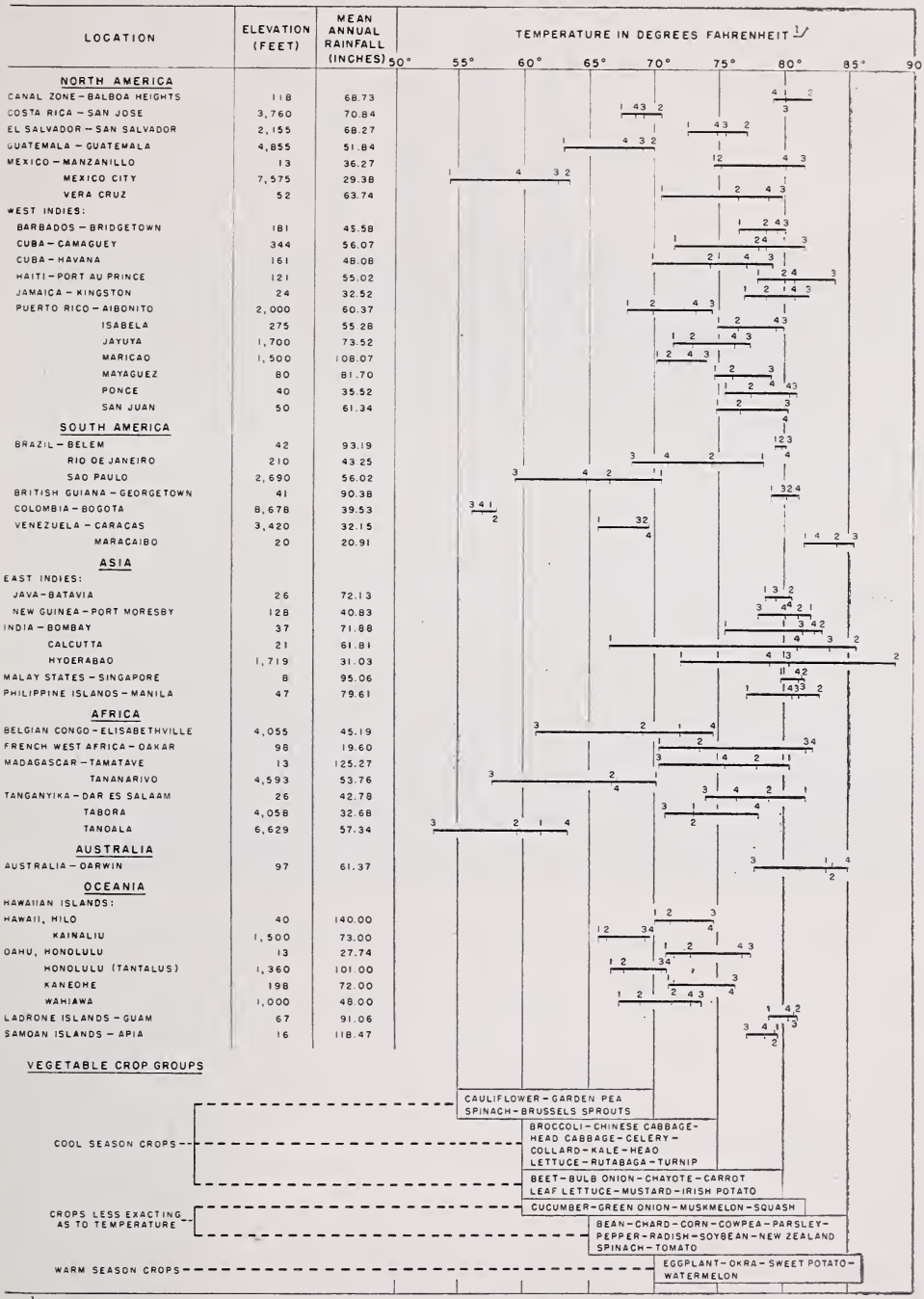
McClelland (*27*) has shown that in Puerto Rico such varieties of bulb onion as White Bermuda form bulbs best if they mature during the increasingly longer days of spring, but make vigorous top growth and no bulbs during the short days of winter. Such varieties as Prizetaker and Yellow Globe Danvers formed bulbs only when the day was lengthened to 15 hours by artificial light. With Irish Cobbler, Red Bliss Triumph, and Lookout Mountain potatoes the longer days favored top growth, whereas short days favored tuberization. Red Bliss Triumph was the least sensitive to day length; Lookout Mountain, the most.

In the vegetable trials USDA–34 sweet corn produced the largest stalks and ears when the crop matured in April to June. This was true also of field corn in Puerto Rico (*27*). Likewise, the Seminole soybean produced by far the best crop under these light conditions.

Time of sunrise and sunset varies slightly with longitude in a small area like Puerto Rico. For example, at Toro Negro the sun rises 1 minute, 52 seconds earlier than at Maricao and 2 minutes, 48 seconds earlier than at Mayagüez. There also may be some variation in day length and in sunlight reaching vegetables at a given longitude because of shading from nearby mountains early in the morning or late in the evening, or both. For example, at Maricao, USDA-34 sweet corn grows and produces better at a given season near the top of the mountains than in the deep narrow valleys.

NEED FOR VEGETABLE BREEDING IN THE TROPICS

An extensive, coordinated vegetable-breeding program is greatly needed in the Tropics. Developed through long-time breeding and se-



1/ MEAN TEMPERATURES ARE GIVEN FOR JANUARY (1), APRIL (2), JULY (3), AND OCTOBER (4).

FIGURE 6.—Approximate temperature range required by the more popular vegetables for satisfactory performance, and altitude, annual precipitation, and mean temperatures in January (1), April (2), July (3), and October (4) in several places in the Tropics.

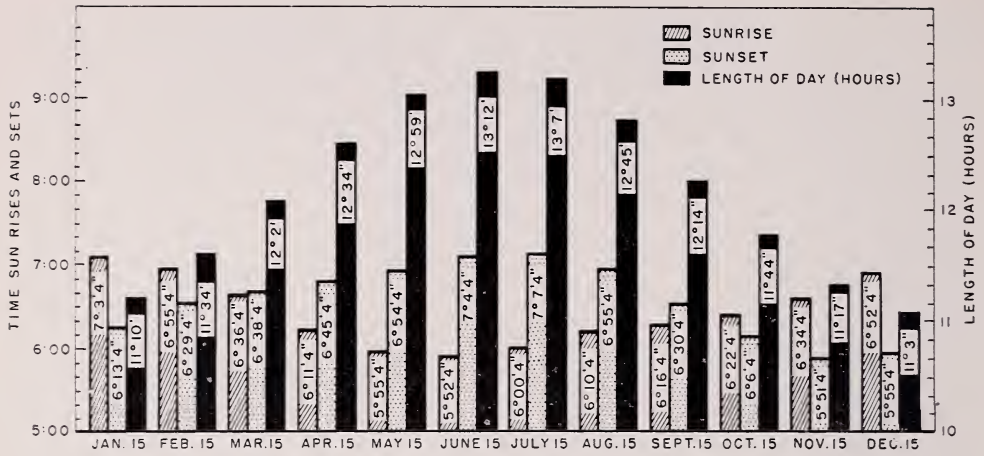


FIGURE 7.—Length of day and time of sunrise and sunset on the fifteenth of each month at Mayagüez, P. R

lection, vegetable varieties in the continental United States are well adapted to temperate climates. Although some varieties developed in the Temperate Zone perform satisfactorily when planted at specific seasons and elevations in the Tropics, this is not true of all. The few varieties that have been developed in the Tropics—USDA-34 sweet corn, Pearl Harbor tomato, Indian cauliflower, Puerto Rico No. 39 mildew-resistant cucumber, mosaic-resistant peppers, wilt-resistant Rosita eggplant, improved dry beans (Nos. 1362, 1395, and 1329), and others—are more productive and easier and less expensive to raise than continental varieties. Likewise, the tropical varieties developed by crosses between continental varieties and low-quality disease- or insect-resistant native stock often do better in the United States than the standard varieties.

Several varieties of any given vegetable are needed for different regions and climates in the Tropics. Thus, in the small land area of Puerto Rico a half dozen varieties of tomato may not be sufficient. A variety that performs satisfactorily during winter at Mayagüez might be outyielded in summer by another variety which tends to set a heavier crop under higher temperature conditions. Also, a variety which performs better in winter at Mayagüez might perform equally well in summer at Maricao, whereas another variety might show best performance only during the very cool winter at the still greater altitude of Toro Negro.

GENERAL GARDENING SUGGESTIONS

Choosing Location and Crops

GARDEN LOCATION—A good garden site should meet as nearly as possible the following specifications:

1. A somewhat flat, or gently sloping surface. (Steep slopes are undesirable unless bench terraced (fig. 8).)
2. Well-drained loamy soil, high in organic matter and plant nutrients.
3. Protection from winds by windbreaks or neighboring hills (fig. 5, *D*).

4. Location beyond the range of roots and shade of trees and hedges that might compete with the vegetables for light, water, and nutrients. (Shade of a distant high tree on the sunny side of cool-season crops, however, may assist in lowering the temperature at midday, thus making it possible to grow the crop over a longer season.)
5. Near home and not readily accessible to thieves.
6. A water faucet or unpolluted stream nearby for source of irrigation water.
7. Near the market, if some or all of the produce will be sold for profit.
8. Protection from animals.

FIGURE 8.—Vegetables growing on a hand-made terrace built on a 45-percent slope near Maricao. Water is piped by gravity for irrigation and spraying.

CROPS AND VARIETIES TO PLANT.—In the Tropics above the Equator most vegetables grow better during the cool, relatively dry winter season between October and May than during the warm, rainy summer months. Local environment is also a factor (p. 3). In general, vegetables that have performed moderately well to well the year round under Puerto Rican conditions at sea level are beet, cabbage, carrot, Ceylon spinach, chard, Chinese cabbage, eggplant, gandul (pigeonpea), green bean, green onion, leaf lettuce, mustard, okra, pepper, radish, sweetpotato, tomato, cassava, and yautía (tanier). All these vegetables, particularly broccoli, cabbage, and Chinese cabbage, performed better during the cool dry season than during the warm rainy months. On the other hand, okra, pepper, eggplant, and New Zealand spinach performed somewhat better during the warm season than during the cool. Tomatoes perform best during the relatively dry season. Table 3 lists vegetable varieties suitable for planting in the Tropics. Additional varieties are suggested for the Virgin Islands by Thompson (*52*).

TABLE 3.—*Vegetable varieties likely to succeed in the Tropics*[1]

Crop	*Varieties*	*Remarks*[2]
Asparagus	Giant Washington, Mary Washington.	May be grown from seed or divisions.
Bean:		
Bonavist or Hyacinth (*Dolichos lablab* L.)	White-, brown-, or black-seeded.	Seed may be obtained from local markets.
Bush green	Bountiful, Stringless Greenpod, Plentiful, Logan Tendergreen, Puerto Rico Improved White varieties, Puerto Rico Red Kidney.	Other varieties (p. 50) probably as satisfactory.
Bush wax	Pencil Pod Wax, Surecrop Stringless Wax.	----------
Pole green	Kentucky Wonder.	Other varieties may be as satisfactory.
Bush lima	Burpee Bush, Improved Fordhook Bush, Fordhook 242.	----------
Pole lima	Early Leviathan, Ford Mammoth, Burpee Sunnybrook, King of the Garden.	The last will bear for several years if protected from insects.
Beet	Early Wonder, Crosby Egyptian, Detroit Dark Red, Improved Blood Red.	Other varieties may perform satisfactorily. Tops of all these table varieties may be used for greens.
Broccoli	Calabrese.	----------
Brussels sprouts	Improved Long Island.	----------
Cabbage	Golden Acre, Copenhagen Market, Early Jersey Wakefield, Marion Market, Succession, Wisconsin All Seasons.	First three are early varieties with small heads. Succession is among the best with large heads.
Cabbage, Chinese	Chi-Hi-Li, Wong-Bok, Pe-Tsai.	First was generally most satisfactory.
Cantaloup	Texas Resistant No. 1, Smith Perfect, Local varieties.	----------
Carrot	Danvers Half Long, Improved Red Cored Chantenay.	First is more productive.
Cauliflower	Early Patna, Early Market, Royal Purple.	First two are Indian strains. Royal Purple produces heads with purple tint.
Celery	Yellow Self Blanching, Utah.	First most commonly used.
Chard, Swiss	Lucullus, Fordhook Fancy, Rhubarb.	Rhubarb chard has red petioles.
Chayote	Cream or white.	Select desirable type fruit from market.
Collards	Georgia, Louisiana Sweet.	----------
Corn, sweet	USDA-34.	Low to medium altitudes only.
Cowpea:		
Pole	Yardlong.	Do.
Bush	Brown Crowder, Cream Lady, Blackeye.	Do.
Cucumber	Puerto Rico 39, Long China, Henderson, Straight Eight.	First is most mildew resistant
Eggplant	Rosita, Puerto Rico Beauty, Black Beauty, Ft. Meyers Market.	First has white fruits blotched with pale purple.
Endive	Broad Leaved Batavian.	Partially self-blanching.
Garlic	Any variety available.	Bulbs are divided into cloves for planting.
Kale	Dwarf Siberian, Blue Curled Scotch.	Curled varieties more attractive but likely to harbor insects.

Crop	*Varieties*	*Remarks*[2]
Kohlrabi	Short Leaved Early White Vienna.	----------
Leek	American Flag.	----------
Lettuce:		
Heading	Great Lakes, Imperial 847 and 44, Mignonette.	Mignonette is most heat-resistant and may be grown in summer as leaf lettuce.
Leaf	Slobolt, Black Seeded Simpson, Mignonette.	First is slowest to send up seed-stalks in warm weather.
Mustard	Florida Broad Leaf, Fordhook Fancy, Southern Giant Curled, Tendergreen.	Other varieties probably as suitable. Curled varieties likely to harbor insects.
Okra	White Velvet, Perkins Long Green.	First a favorite locally.
Onion:		
Bulbing	Louisiana Red Creole, Yellow Bermuda.	Seed must be fresh.
Green	"Cebollín" (native Puerto Rican), New Long White Bunching.	First is propagated by division only; second by division or seed.
Parsley	Extra Curled Dwarf, Moss Curled, Paramount, plain or single.	Curled varieties have not produced seed in Tropics.
Parsnip	Hollow Crown.	Other varieties probably as satisfactory.
Parsnip, Peruvian ("Apio" in Puerto Rico).	"Venezolano"	Obtain planting stock locally.
Pea:		
Edible-podded	Melting Sugar, Dwarf Gray Sugar.	First is a white-seeded variety which may be eaten as shelled peas.
English	Telephone, Alderman.	Both are tall.
Pepper	"Blanco" (Puerto Rico native), California Wonder, Puerto Rico Selection No. 21, Ruby King.	First has thin pale-green flesh, others thick dark-green flesh before ripening.
Pigeonpea (gandul)	"Totiempo" or local varieties.	Fresh seed should be obtained locally.
Potato	Red Bliss Triumph, Green Mountain, Katahdin.	----------
Pumpkin	Alagold, Large Cheese, Small Sugar.	First superior in flavor.
Radish	Earliest Scarlet Button, Earliest Scarlet Globe, Long White Icicle, Sparkler.	Other varieties may perform equally well.
Rhubarb	Victoria.	Planted from seed.
Rutabaga	American Improved.	----------
Salsify	Mammoth Sandwich Island.	----------
Soybean	Seminole.	----------
Spinach:		
Ceylon (Malabar Nightshade)	Ceylon.	Propagated by seed or cuttings.
New Zealand	New Zealand.	Soak seed for 24 hours before planting.
Squash	Black Zucchini, Cocozelle Bush, Yellow Summer Crookneck, Golden Straightneck, "Calabaza" (native Puerto Rican).	First four are summer squash varieties.
Sweetpotato	Red Velvet, Mameya, Morado, Don Juan, Totiempo.	----------
Tanier (Yautía)	Any available locally.	Select best types from market.
Taro (Malanga) or dasheen	do.	Do.

Crop	*Varieties*	*Remarks*[2]
Tomato	Marglobe, Michigan State Forcing, Pritchard, Rutgers, Plum, Cherry, Pear, Bounty.	Hybrids not thoroughly tested in Tropics.
Turnip	Purple Top White Globe, Shogoin.	Second a foliage turnip, grown largely for greens.
Watermelon	Improved Tom Watson.	Better variety needed.
Yam	Guinea, Ceylon, Mapuey, Potato, Tongo, "Agua," or any available.	First four most desirable.

[1] It is suggested that the gardener consult local growers and agricultural institutions for further recommendations on varieties which have performed satisfactorily in his locality.

[2] See section on cultural management of individual crops, pp. 46-91.

In selecting vegetables for the garden their nutritive value should be considered. Among the root crops, carrot is highest in vitamins and minerals, but relatively low in food value. Legumes, such as green beans, lima beans, cowpeas, and soybeans, are high in vitamins, minerals, and protein. Vegetables of the greens group, such as broccoli, chard, lettuce, mustard, and parsley, are valuable. Vegetables of the starchy type, such as potato, sweetpotato, and corn, are primarily energy foods. Under usual home-garden conditions the area available is not large enough to grow enough of these starches for family consumption, which should be raised only when plenty of space is available. This is also true for cucumber, pumpkin, watermelon, and squash, which are low in food value. However, yellow-orange squashes are rather high in vitamin A content.

Planting Plans

To make the best possible use of land throughout the year, an advance planting plan of the garden should be prepared. The accompanying plans for small, medium, and large gardens at different altitudes and mean-temperature levels should serve merely as guides. Each gardener may want to make substitutions for some of the crops to suit his own tastes and conditions. The plans cover altitudes and approximate mean annual temperatures of: (1) Sea level to 1,000 feet elevation at 76°F.; (2) 1,000 to 2,500 feet at 73°; and (3) 2,500 to 3,500 feet at about 68°.

In selecting vegetables the gardener should examine the data in figure 6 in order to choose crops which are likely to perform most satisfactorily under his environmental conditions. He should then check his selection individually with the section on cultural management of the different vegetables (p. 46) to determine other specific requirements. He must remember that below the Equator the seasons are the reverse of those above. For example, at Tamatave, Madagascar (*37, p. 682*), about 15° south of the Equator, the cool dry season is at its peak around July (70.5°F.), while the warm rainy period is around January (80.5°). Near and on the Equator the mean temperature varies but little throughout the year. Thus, at Quito, Ecuador, which is almost on the equatorial line, the mean temperature varies from 56.6° in July to 58.0° in October (*37, p. 675*). In view of these seasonal differences throughout the Tropics, the planting dates in the accompanying plans for cool- and warm-season crops will need to be adjusted according to local conditions.

Plants, such as broccoli, cabbage, eggplant, onion, pepper, and tomato, which require transplanting from flats, pots, or seedbeds, should be planted 3 to 6 weeks early so that they will be properly developed for transplanting to the garden on the dates recommended in the plans.

It must be recognized at the outset that to obtain good yields of top-quality vegetables, the garden must receive some attention almost daily, with a total of several hours a week. An inexperienced gardener should start with a small area of ground and a few crops; then expand to a larger garden and greater diversity of vegetables as interest and experience develop.

Medium-size garden plans are suggested for sea level to 1,000 feet and from 1,000 to 2,500 feet. Only a small garden plan is suggested for altitudes and temperature conditions from 2,500 to 3,500 feet. Where additional land is available, a supplementary plan is given for increasing the size of the small and medium-size gardens to provide a larger quantity and variety of vegetables. In the absence of natural protection some provision for windbreaks should be made in these garden plans (p. 26).

The planting date for gardens at sea level has been suggested as October 15 and at the higher elevations as December 1, as these dates are common for starting gardens in the West Indies. These dates are entirely arbitrary, however. It is possible to start a garden at almost any time, using the dates in the planting plans.

A wide variety of produce will not necessarily be available in these gardens at all times of the year, but it is not intended—in fact, conditions do not make it possible—to have all the crops listed during every month. Where rainfall is likely to be heavy at times, it is recommended that raised beds be constructed (p. 33), particularly during the rainy season, in order to obtain optimum drainage. When not in use the ground in certain areas should be manured, dug up, and left fallow until needed.

Garden plan for sea level to 1,000 feet; annual mean temperature about 76°F.—The garden plan in figure 9 and table 4 covers an area 30 by 50 feet, divided into 8 plots by walks. With good use of the land throughout the year and proper disease and insect control, a garden of this size should provide enough green vegetables for a family of four or five. A few starchy vegetables, such as sweetpotato, yautía, and potatoes, could be grown in a garden of this size only by judicious management and companion cropping. The sweetpotato and other vine crops might be grown on the fence to provide a windbreak.

Vegetables which can be substituted for those in the plan include bulb onion, broccoli, kale, kohlrabi, squash, mustard, cucumber, sweet corn, and collards grown in their proper season. Broccoli can be substituted for cabbage in November or January. Chinese cabbage can be substituted for cabbage at any period of the year, but both of these crops produce best in the cool season. Soybeans of the Seminole variety can be substituted for lima or green beans, particularly when starting in April.

With the tomato it may be advisable to use two varieties such as Bounty and Michigan State Forcing with a 15-foot row of each. Bounty comes into bearing 2 to 3 weeks earlier than the Michigan State, but bears lighter and over a shorter period. An alternative is to plant a 15-

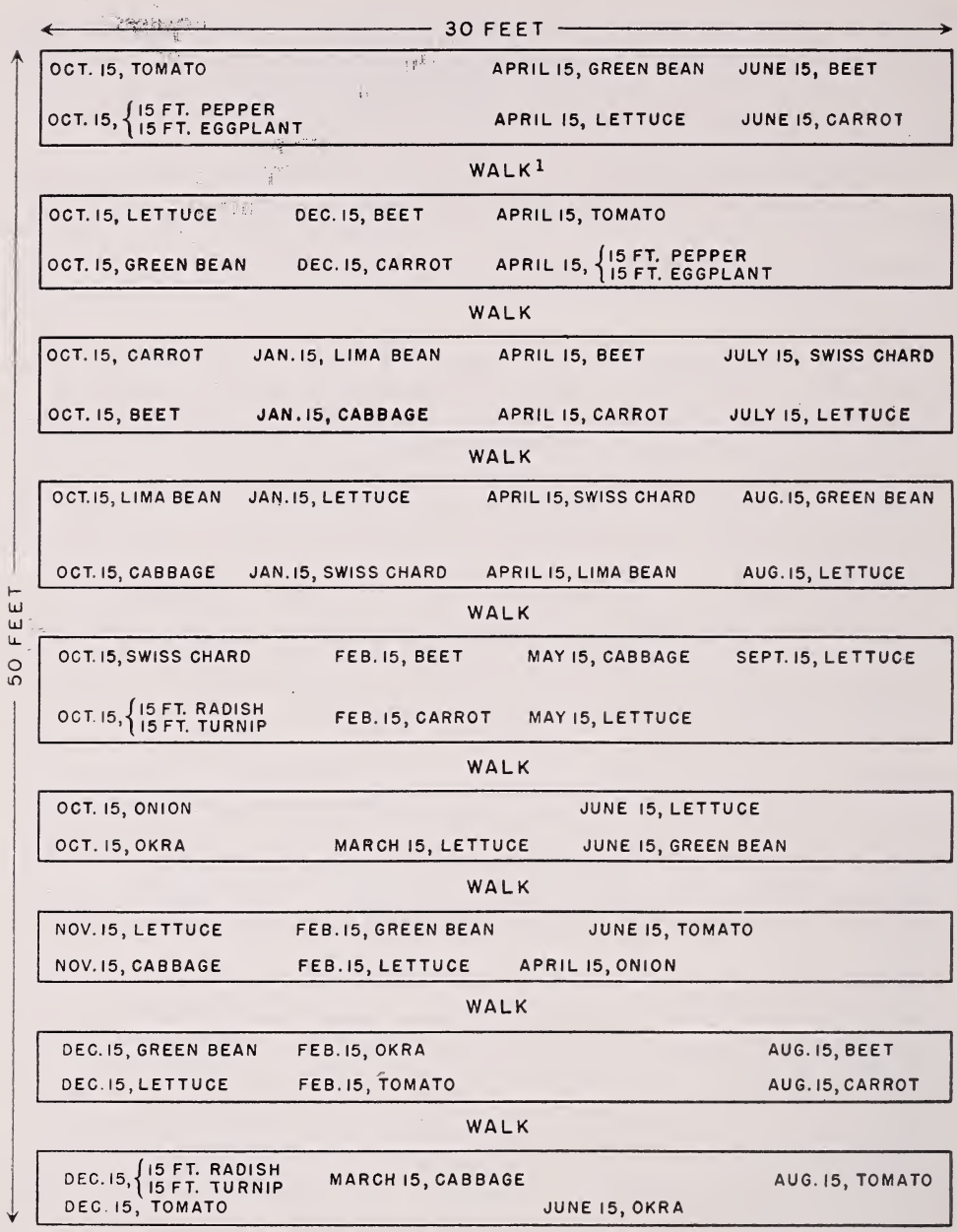


FIGURE 9.—Suggested planting plan for a medium-size home vegetable garden at sea level to 1,000 feet, maintained 12 months of the year. (See also table 4.)

[1] Walks should be at least 2 feet wide; for recommended spacing between rows of vegetables consult table 10, p. 42.

foot row each month of only one variety, such as Michigan State Forcing, rather than a 30-goot row every 2 months. It may be desirable to use a few plants of the small-fruited plum-, cherry-, or pear-ype tomatoes during the summer. Tomatoes of this type are more likely than the others to bear a satisfactory crop under adverse conditions at low elevations.

TABLE 4.—*Length of rows for vegetables in a medium-size home garden at low elevations*

[Sea level to 1,000 feet; annual mean temperature, about 76°F.]

Crop	Length of row when planted in—											
	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Bean, green	30		30		30		30		30		30	
Bean, lima	30			30			30					
Beet	30		30		30		30		30		30	
Cabbage	30	30		30		30		30				
Carrot	30		30		30		30		30		30	
Eggplant	15						15					
Lettuce	30	30	30	30	30	30	30	30	30	30	30	30
Okra	30				30				30			
Onion, bunching	30						30					
Pepper	15						15					
Radish	15		[1]15									
Swiss chard	30			30			[2]30			[2]30		
Tomato	30		30		30		30		30		30	
Turnip	15		15									

[1] May be sown broadcast between rows of other crops.

[2] New Zealand spinach could be substituted for one or two summer plantings.

By doubling the size, this garden could also be made to produce most of the starchy vegetables required by a medium-size family. The plan suggested in figure 10 and table 5 for increasing the size of gardens at medium elevations also can be used here. It might be desirable to eliminate the crop of dry shell beans and grow more sweet corn and sweetpotatoes.

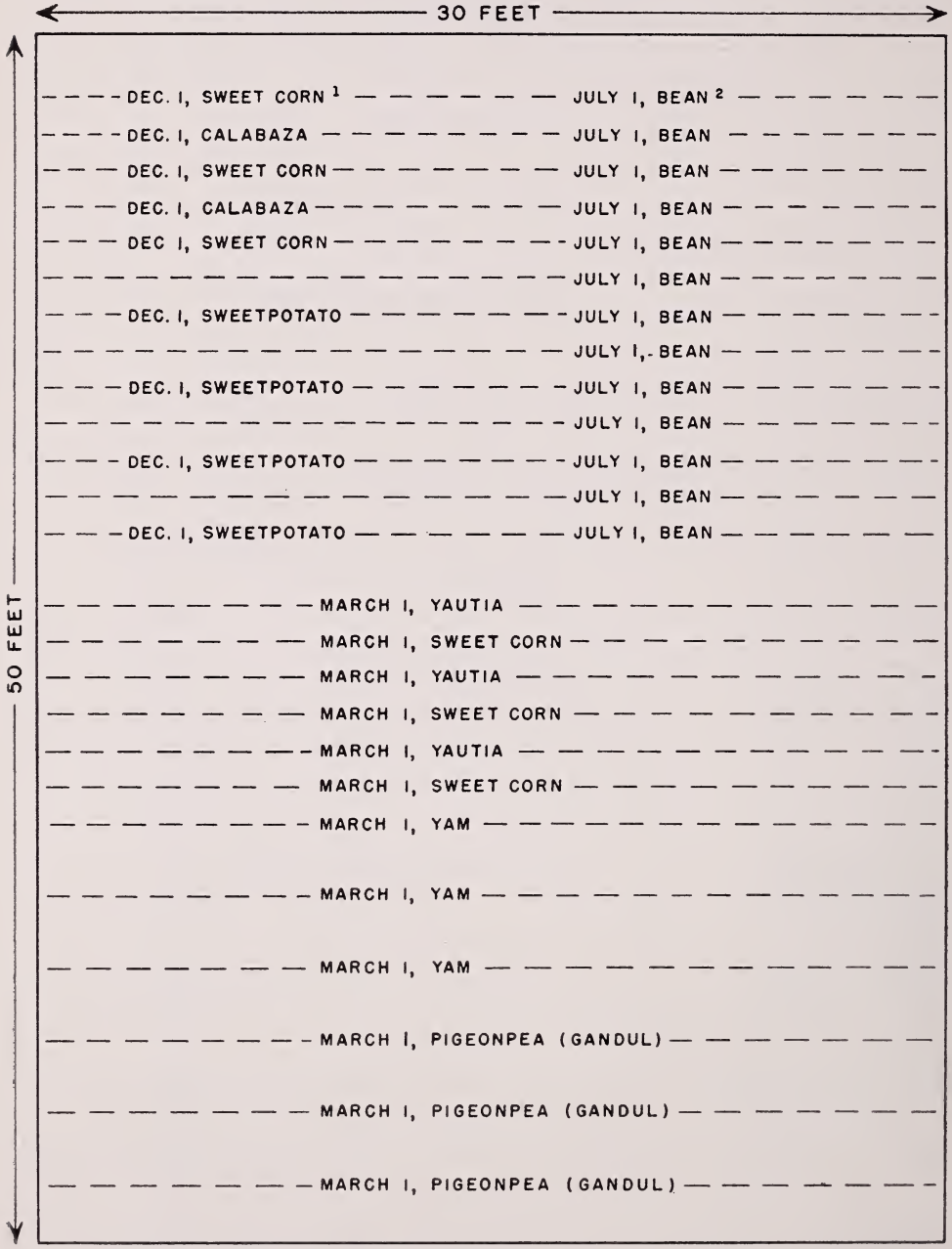


FIGURE 10.—A suggested 12-month planting plan for increasing the size of a medium-size or small garden. (See also table 5.)

[1] Rows of sweet corn, sweetpotato, yautía, yam, and gandul are 3 feet apart; bean rows are 18 inches apart.

[2] For dry shell beans, such as Puerto Rico White.

PLAN FOR MEDIUM-SIZE GARDEN AT 1,000 TO 2,500 FEET ALTITUDE; ANNUAL MEAN TEMPERATURE ABOUT 73°F.—Suggestions given for the medium-size garden at low elevations (fig. 9 and table 4) apply for the most part to the garden suggested in figure 11 and table 6 for middle elevations. However, with the approximately 3-degree cooler mean temperature the cool-season crops, such as kohlrabi, cabbage, Chinese cabbage, and broccoli, will perform slightly better and over a longer

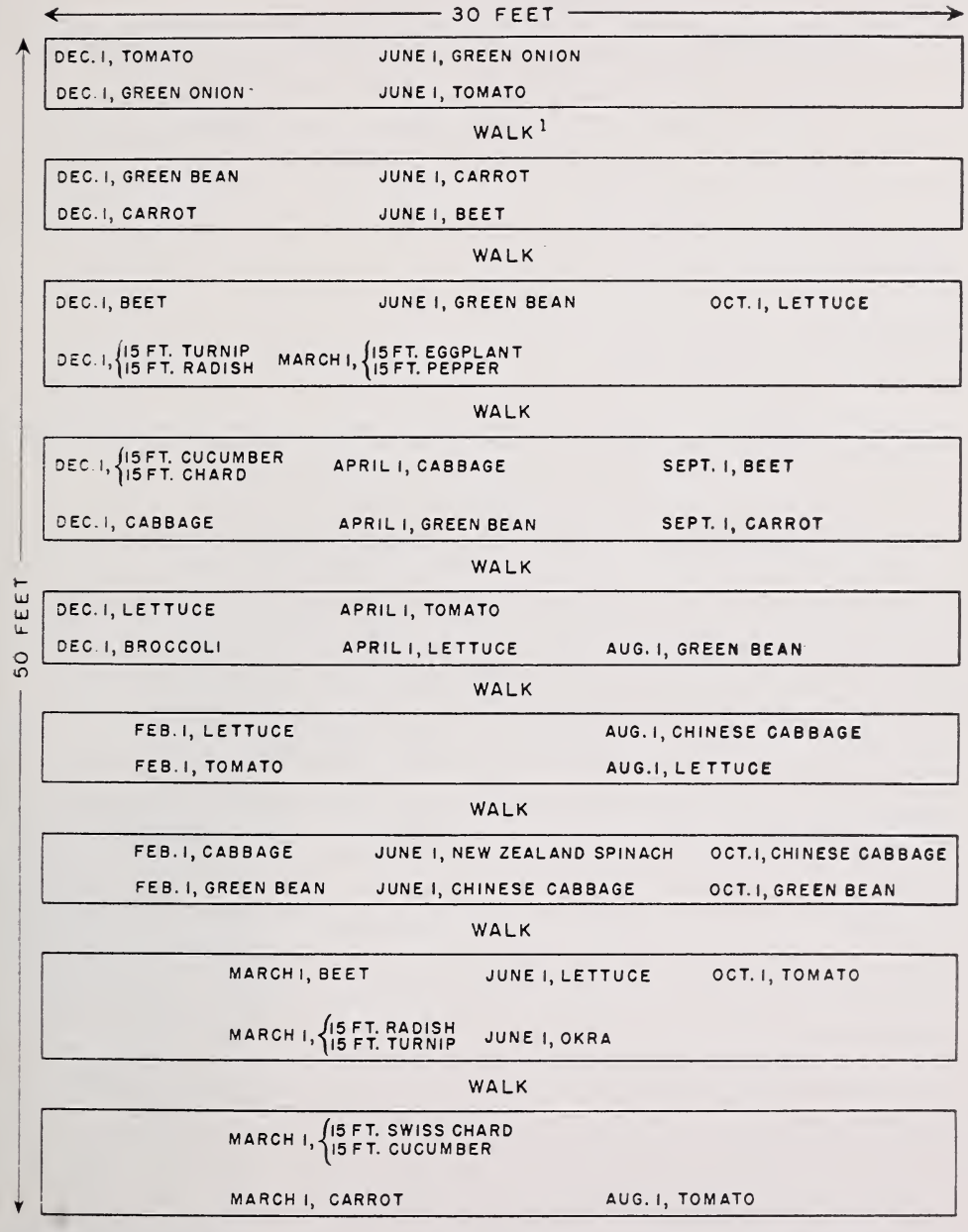


FIGURE 11.—Suggested 12-month planting plan for a medium-size vegetable garden at 1,000 to 2,500 feet altitude. (See also table 6.)

[1] Walks should be at least 2 feet wide; for recommended spacing between rows of vegetables consult table 10.

season. On the other hand, warm-season crops, such as eggplant, okra, and pepper, will perform better during the warm months. If extra land is available, the size of this garden can be increased by adding the crops shown in figure 10 and table 5.

TABLE 5.—*Length of rows for additional crops to increase medium-size to large home gardens*

Crop	Length of row when planted in—		
	December	March	July
	Feet	*Feet*	*Feet*
Bean, bush, shell			275
Calabaza	50		
Gandul		75	
Sweet corn	75	75	
Sweetpotato	75		
Yam		75	
Yautía		75	

TABLE 6.—*Length of rows to be planted to vegetables in a 30-by-50-foot home garden at medium elevations*

[1,000 to 2,500 feet: annual mean temperature about 73°F.]

Crop	Length of row when planted in—							
	Dec.	Feb.	March	April	June	Aug.	Sept.	Oct.
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Bean, green bush	30	30		30	30	30		30
Beet	30		30		30		30	
Broccoli	30							
Cabbage	30	30		30				
Cabbage, Chinese					30	30		30
Carrot	30		30		30		30	
Chard	15		15					
Cucumber	15		15					
Eggplant			15					
Lettuce	30	30		30	30	30		30
Okra					30			
Onion, green bunching	30				30			
Pepper			15					
Radish	[1]15		15					
Spinach, New Zealand, or mustard					30		30	
Tomato	30	30		30	30	30		30
Turnip or kohlrabi	15		15					

[1] May be sown broadcast between rows of other crops.

PLAN FOR SMALL GARDEN AT 2,500 TO 3,500 FEET ALTITUDE; ANNUAL MEAN TEMPERATURE ABOUT 68°F.—A small garden plan is suggested for high elevations (fig. 12 and table 7) because this is the most common size for gardens at such altitudes. This may be the result of remoteness from large cities, which are a good outlet for surplus garden vegetables,

or of the character of the land, which is steeper, less fertile, and somewhat less suited to vegetable growing than that at low elevations. Produce from this garden should meet the needs of a family of two or three.

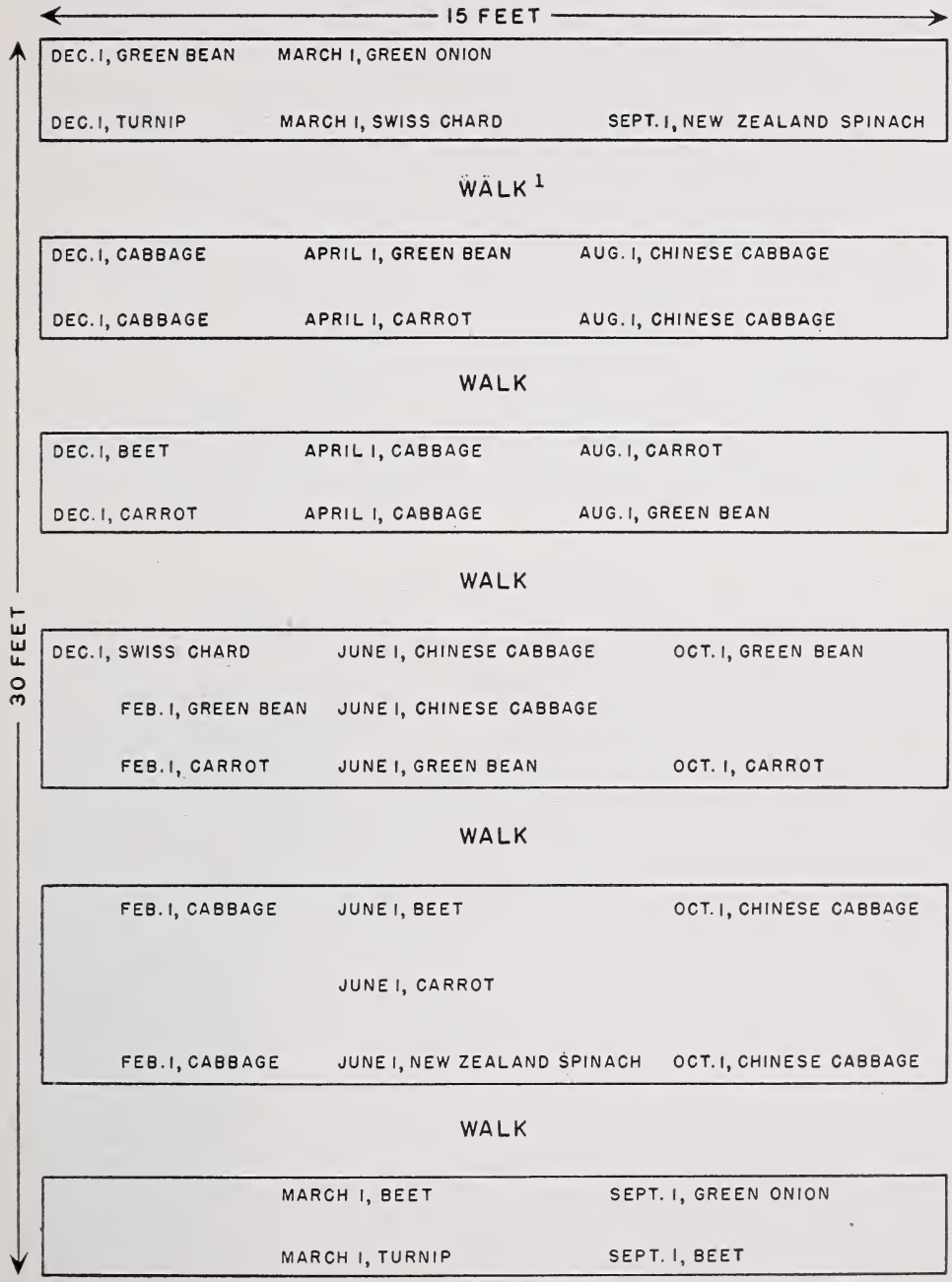


FIGURE 12.—Suggested 12-month planting plan for a small garden at 2,500 to 3,500 feet altitude. (See also table 7.)

[1] Walks should be at least 2 feet wide; for recommended spacing between rows of vegetables consult table 10.

TABLE 7.—*Length of rows to be planted to vegetables in a 15- by 30-foot garden at high elevations*

[2,500–3,500 feet: annual mean temperature about 68°F.]

Crop[1]	Length of row when planted in—							
	Dec.	Feb.	March	April	June	Aug.	Sept.	Oct.
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
Bean, green bush	15	15	----	15	15	15	----	15
Beet	15	----	15	----	15	----	15	----
Cabbage	30	30	----	30	----	----	----	----
Cabbage, Chinese	----	----	----	----	30	30	----	30
Carrot	15	15	----	15	15	15	----	15
Chard	15	----	15	----	----	----	----	----
Onion (bunching)	----	----	15	----	----	----	15	----
Spinach, New Zealand, or mustard	----	----	----	----	15	----	15	----
Turnip or kohlrabi	15	----	15	----	----	----	----	----

[1] In addition, lettuce and radishes may be interplanted with other crops.

There is no reason why this small garden cannot be expanded by adding crops adapted to higher altitudes. At high elevations such warm-season crops as eggplant and okra should be planted only in a small way for trial. Pepper, on the other hand, may give fair yields during the warmer months. True spinach also may fail unless the mean temperature is below about 65°F.; true spinach varieties were a failure at 68°F. in the Toro Negro trials. Other crops which may be included or used as replacements for those suggested in figure 12 and table 7 at high elevations include rhubarb, broccoli, parsley, asparagus, celery, collard, cauliflower, endive, kale, leek, mustard, parsnip, pea, potato, rutabaga, and salsify. Sweetpotato and sweet corn of the presently available varieties usually do not produce very well at high elevations.

At altitudes above 3,500 feet and mean temperatures below 65°F., the number of vegetables that can be produced decreases during the cold months; in fact, most vegetables may produce best during the warmer months under these conditions.

Garden Management

COMPANION CROPPING.—Companion cropping, or intercropping, is the growing of two or more vegetables at the same time in alternating hills, rows, or other arrangement on the same area of ground (fig. 13). As land around houses is frequently limited, it is wise to make the most of the available area by intensive use, as, for example, by planting radishes or leaf lettuce in or between rows of sweet corn, tomato, okra, eggplant, and pepper. Radishes also can be effectively planted between rows of onion, chard, bean, carrot, and similar crops. When planted at the same time as the more slowly maturing crops, the short-season crop can be harvested within 30 to 40 days—before competition and shading from the companion crop become limiting factors.

FIGURE 13.—Better use of land often may be accomplished by interplanting comparatively short- and long-season crops.

A. Interplanted Rosita eggplants will mature before crowded by Mary Washington asparagus.

B, Don Juan sweetpotatoes grown between trees of *Psidium brasiliensis* at Puerto Rico Agricultural Experiment Substation, Isabela.

SUCCESSION PLANTING.—In the Tropics several vegetable crops can be grown on the same ground during a 12-month period by planting another vegetable as soon as the first has been harvested. This is known as "succession planting." Enough time should be allowed between each crop to plow, pulverize, and properly prepare the soil for the next crop.

CROP ROTATION.—If plenty of land is available, better results can be obtained by rotating a given crop back and forth between two or three areas. The same crop, or a closely related one, should not be planted on the same ground time after time during the same year. Besides depleting the soil of nutrients, this favors build-up of diseases and insects on that particular crop. Vegetables like tomato, potato, and beans, in particular, which are susceptible to a large number of diseases, should be rotated from one garden site to another. In small gardens it is difficult to avoid some succession plantings of one crop on the same soil, but it is particularly important to avoid succession plantings of the cole crops, which include cabbage, Chinese cabbage, kohlrabi, radish, turnip, Brussels sprouts, cauliflower, mustard, and rutabaga. Eggplant after tomato or vice versa is not advisable, nor is root crop after root crop or bean after bean. Examples of good sequences are as follows (*13, p. 15*):

Crop to be followed	*Crop to be planted*
Beet or chard	Bean, tomato, eggplant, okra, cabbage, lettuce, or onion.
Cabbage or broccoli (any type)	Chard, lettuce, onion, beet, carrot, bean, tomato, or eggplant.
Lettuce	Bean, carrot, cabbage, beet, onion, radish, turnip, or tomato.
Onion	Bean, radish, cabbage, beet, lettuce, carrot, or turnip.
Carrot	Lettuce, broccoli, cabbage, bean, New Zealand spinach, or onion.
Radish	Bean, chard, eggplant, tomato, okra, lettuce, or onion.
Turnip	Chard, onion, New Zealand spinach, bean, eggplant, or tomato.
Cowpea or bean	Beet, chard, broccoli, cabbage, lettuce, onion, tomato, eggplant, or carrot.
Eggplant	Beet, chard, broccoli, cabbage, lettuce, onion, carrot, or radish.
Tomato	Broccoli, cabbage, chard, lettuce, onion, carrot, beet, radish, turnip, bean.

WINDBREAKS.—Windbreaks are almost a necessity for most planting sites under tropical conditions, particularly in insular climates. In the lowland area near Mayagüez, P. R., for example, where vegetable trials were conducted, windbreaks were not necessary because the grounds were surrounded on three sides by hills and the areas immediately around the experimental area had tall houses and trees. At Maricao, however, where a 30-by-70-yard opening was cleared in an exposed mountain-side forest, it was necessary to use individual windbreaks in winter and spring, particularly for the cucurbit and cole crops despite the fact that the garden area was surrounded by 25-foot trees (fig. 5, *C*). Wind dipped into the garden area, developing a twirling motion which eventually twisted many of the plants in two (fig. 5, *A*). This was especially troublesome with such seedlings as squash and bean,

which were broken off at ground level. At Toro Negro the garden was surrounded on three sides by tall, tapering mountains, which, with the forest trees, made a special windbreak unnecessary. In the exposed lowland area near the Puerto Rico Agricultural Experiment Substation at Isabela, a 30-to-35-mile-an-hour continuous wind necessitated substantial windbreaks. In this area coconut palm leaves or war-surplus camouflage cloth mounted on wood-and-wire skeletons (fig. 5, *B*) proved effective for a distance of 30 to 40 yards on the leeward side. Rows of banana, sorghum, papaya, elephant grass, pigeonpea, a tall bamboo (preferably a species of industrial value, such as *Bambusa tulda* Roxb.)[6] or a sugarcane field also constituted windbreaks in this area. A fence covered with vines of pole bean, chayote, sweetpotato, cucumber, or yam may also serve the double purpose of food supply and windbreak.

Irrigation.—Where irrigation is not available, gardens in the West Indies are frequently planted in October, when the rainy season is tapering off, to benefit from the light rains before the dry season sets in. If, however, a garden is to be maintained throughout the year and good production of high-quality vegetables is desired, some provision for irrigation with unpolluted water is essential. Dry periods of 2 to 3 weeks or more are not uncommon during the rainy season, and rainfall in the dry season is not sufficient to support good plant growth. Plants judiciously irrigated grow more evenly and faster, are of better quality, and yield two or three times as much as those that do not get enough water. Radishes grown slowly under drought conditions are bound to be pithy and "hot." The same is true for endive, lettuce, cabbage, and the root crops. In most areas a good irrigation once a week to a depth of 4 to 6 inches is sufficient. In sandy soil two or three irrigations may be necessary. One heavy irrigation is much better than several light superficial waterings applied once or twice a day, except possibly for leaf lettuce, where daily sprinkling seems to help increase the size of the leaves. Sweetpotatoes also respond well to frequent light waterings. Late afternoon is the best time for irrigation in the garden; morning irrigations are probably better for the seedbeds, where damping-off disease may be a problem.

Hydraulic rams are sometimes used in hilly sections to drive the water economically from a low stream to high ground (fig. 14, *D*). It may be possible to provide water by gravity from a mountain spring (fig. 8). Where land is almost level, furrow irrigation is the most satisfactory for vegetables, particularly lettuce, tomato, and bean, which are susceptible to leaf diseases. When plants are transplanted to the field during the dry season, they should be set in the bottom of the irrigation furrow if the soil is sandy, or at the side of the furrow if the soil is of a heavy type, in order to receive full benefit from the irrigation water (fig. 14, *G*). When the plants become large the furrow is shifted to between the rows. If the beds are level, the surface of the soil can be flooded by building a small dike around the outside.

Sprinkler, or overhead irrigation (fig. 15) calls for more expensive equipment, the water may wash sprays and dust materials from the leaves, and the extra wetting of the leaves may encourage fungus diseases. However, if the land is rolling, the soil light in texture, and the

[6] Consult your local experiment station, or the Federal Experiment Station at Mayagüez, P. R., for propagation material and planting instructions.

FIGURE 14.—*A*, USDA–34 sweet corn, a widely planted variety for the Tropics, developed by the Federal Experiment Station.

B, Field of staked Marglobe tomatoes at Borinquen Army Air Base near Aguadilla.

C, Improved variety of snap bean (No. 1329) developed by Puerto Rico Agricultural Experiment Substation, Isabela.

D, Leek near Yauco. Note 50-gallon drums in background for storing irrigation water from hydraulic ram at stream level a few hundred feet below.

E, Mallorquín pepper in summer at Mayagüez; seed came from Spain.

F, Hot pepper varieties grow vigorously and fruit heavily at Mayagüez.

G, Tomatoes at Puerto Rico Agricultural Experiment Substation, Isabela. Note method of planting on upper side of ridges to facilitate furrow irrigation.

water supply limited, the sprinkler system is the best (*51, p. 132*). The water may be applied by oscillating pipes or by rotary sprinkler heads (fig. 15). The rotary head system with portable pipe is popular in the United States. The supply lines for the sprinkler system may be portable or permanently installed above or below ground. Additional information on the installation and operation of small and large irrigation systems may be obtained from Rohwer (*42*) and Staebner (*48*).

FREQUENT CULTIVATION ADVISABLE.—A day or two after a good rain or irrigation the ground should be cultivated with a hoe, a hand wheel

FIGURE 15.—Irrigation system used for vegetables in the Tropics. *A*, Gasoline motor-driven pump delivers irrigation water from nearby stream to rotating sprinklers in celery and broccoli fields in *B*; same pump is also used for filling nearby concrete reservoir in *C*, from which water is supplied by gravity to furrow irrigation system in *D*. *E*, Portable oscillating pipe irrigation system: Water from pond is delivered by concrete ditch to sump, then pumped to pipe system by equipment and power similar to that shown in *A*. (*A–D*, at Puerto Rico Agricultural Company farm, Bayamón; *E*, at Federal Experiment Station, Mayagüez.)

cultivator, or motor-driven equipment, to loosen the soil and discourage weeds. Working in the garden too soon after a rain or irrigation, when the soil is muddy, results in puddling, hardening, and cracking of the soil. Weeds are easiest to eliminate while small, most difficult when large, deeply rooted, and heavily competitive with the vegetables. Care should be taken not to cultivate deeper than 1 to 2 inches and to keep

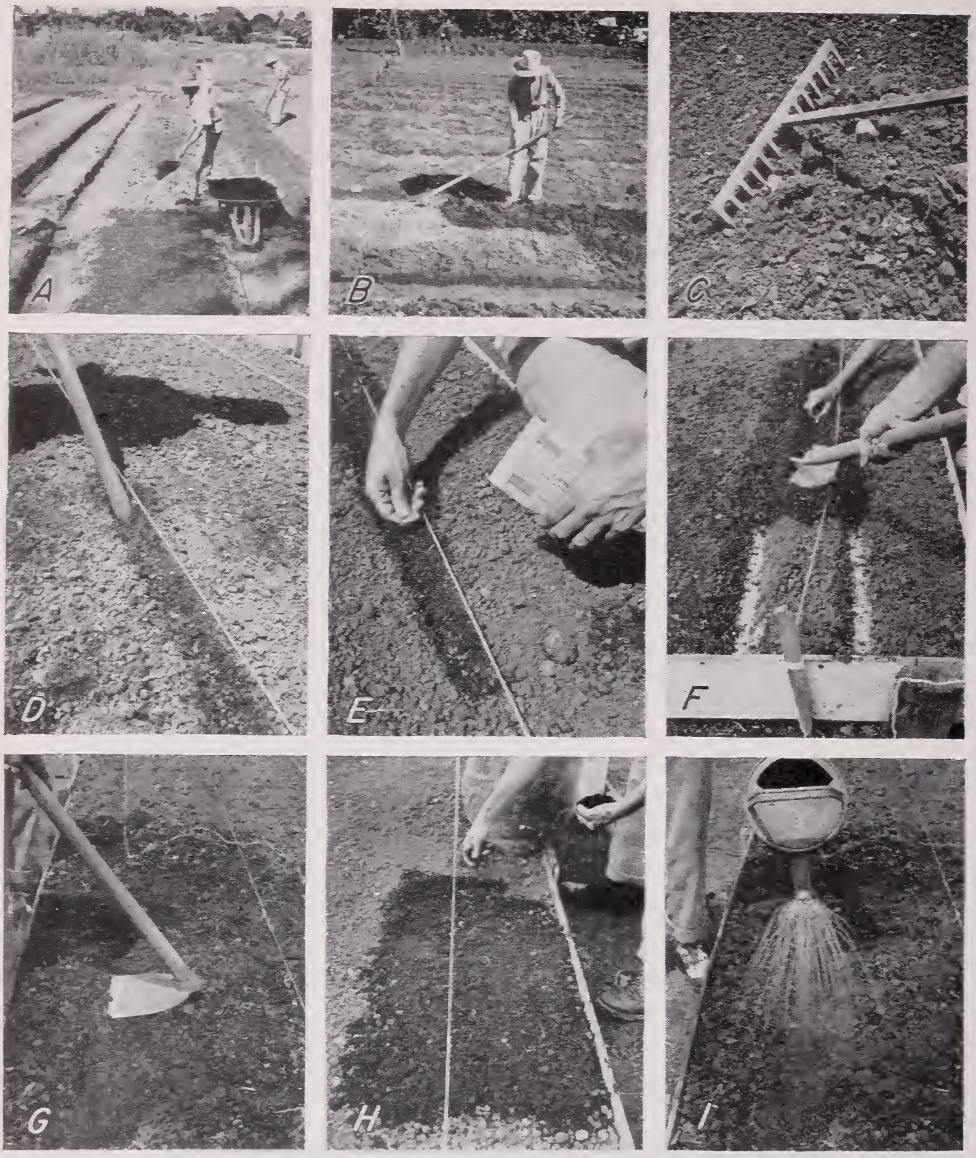


FIGURE 16.—After beds are built up for vegetable growing, a layer of rotted manure is added (*A*), commercial fertilizer (*B*) is applied on top of the manure, after which the upper 3 to 4 inches are thoroughly mixed. A fine seedbed is prepared by removing large clods with a rake (*C*). Furrows for small seeds can be prepared with the end of a hoe handle (*D*). Small seeds, such as turnip, are planted about ½ inch deep (*E*). For large seeds, such as beans and corn, the furrow is made 1½ to 3 inches deep with the corner of the hoe (*F*). (Note recommended strips of complete fertilizer previously applied on the left and right of the seed furrow.) After planting the seed, the soil is pulled over the furrow with a hoe or rake and tamped lightly (*G*). A thin layer of well-rotted manure may be distributed in a strip over the planted seed to help preserve moisture and insure better germination (*H*). When planting is completed, the seedbed area should be well watered (*I*).

the cultivator blades away from the vegetable roots to avoid injury to them. Cultivating will proceed rapidly and easily if *the tools are kept sharp.*

GOOD MULCHING PRACTICE.—Mulching with plant debris conserves soil moisture, reduces weed growth, keeps the soil cool, reduces soil erosion, and adds nutrients. The mulch must be at least 2 inches thick, preferably 3 to 4 inches, to be most beneficial. A moderately heavy mulch aids greatly in tiding the plants over short dry periods; it also reduces the amount of water and number of irrigations needed. Mulch material may be leaves, lawn and tender hedge clippings, cane trash, straw, or similar substances. Plants or vegetable debris which have been diseased or insect-ridden should not be used because of danger of distributing pests and weed seeds over the garden. A thin mulch of rotted manure (fig. 16, *H*), cachaza (filter press cake), lawn clippings, a burlap bag, or banana leaves may be used to cover newly planted seed to maintain an even soil moisture and insure good germination. This is particularly important in low-rainfall or windy areas, where evaporation is important. When the plants begin to appear, the mulch should be pulled aside a little to permit free growth. Subsequently, the mulch can be spaded into the soil for enrichment. Manure or commercial fertilizer, particularly nitrogen, should be applied with a heavy mulch to prevent the crop from developing nitrogen deficiency.

SEED

SOURCE.—The use of seed with poor germination can be a costly mistake. Not only the time and effort of preparing the seedbed will be lost but also the gardener will be without the desired vegetables for some time. It is wise to use fresh seed, ordering the quantity needed for a 6- to 12-month period. Seed not used immediately should be stored in airtight containers over calcium chloride or calcium oxide (quicklime).[7] Layers of cotton and blotting paper should be used between the chemical and the seed (fig. 17). These chemicals keep the air and seed dry within the container, which is essential in maintaining viability under tropical conditions. The container should be kept in a cool place. It has been demonstrated that seed of several different vegetables can be preserved for 2 years or longer, at better than 90-percent germination when stored in this manner (*21, p. 27*). If seed is stored without protection from high humidity and relatively high mean temperatures, sufficient viability to produce good stands of some crops may be lost within a few weeks. Fresh, dry, unleached wood ashes also have been used to preserve the viability of garden seed in the Tropics. Equal volumes of ashes and well-dried seed are thoroughly mixed and stored in a tightly sealed bottle or other container.

The chemicals and chemical compounds recommended in the following pages are all more or less poisonous. Some are highly inflammable; some are caustic and corrosive. Persons unfamiliar with the dangers encountered in the handling, use, and storage of such chemicals should secure expert advice before attempting their use.

Corn seed that has been dried on the cob can be kept free from weevils for several months by rolling the husked ears in lime. When stored without treatment germination may be destroyed within 3 months by

[7] Obtainable at local chemical supply stores or drugstores.

FIGURE 17.—Good germination of vegetable seeds can be preserved under tropical conditions by storing over calcium chloride at room temperature in airtight containers. Thin layers of cotton and blotting paper are used above calcium chloride. Seeds are in packets or cloth bags.

high humidity or weevils or both (*34*). (See Fumigants, pp. 98 and 117, for control of seed-infesting insects.)

The best seed can usually be obtained from Temperate Zone supply houses by ordering about the first of the year instead of in late summer or fall. Seed houses often fill fall orders with old vegetable seed left over from spring plantings in the Temperate Zone. Seed obtained from December to March, however, is usually fresh, as it comes from the previous season's collection.

Treatments for controlling seed-borne diseases which appear on the seedlings, such as damping-off and black rot, are discussed under the section on "Disease and Insect Control." (pp. 101)

GERMINATION TESTS.—If seed has been stored around the house for several months, the gardener should check germination by the following simple test:

Dip a small towel and two plates in boiling water for a few minutes; allow to cool; put the towel in one plate with a few seeds between a fold and invert the second plate over the first to reduce evaporation. Keep the towel continuously moist, but not soaked. Determine percentage germination within 4 to 8 days.

Germination percentage should be at least 50, which indicates that twice as much seed should be sown as suggested in table 10; a 75-percent germination indicates that about a third more seed should be planted than specified in table 10 to obtain approximately 100 percent of the seedlings needed.

GROWING YOUR OWN SEED.—In general, it is not wise under tropical conditions to grow or save seed from a garden. A crop left in the garden for seeding purposes may occupy the land two or three times as long as when it is grown only for the edible portion. If a good local source is not available, seed can be obtained quickly from reliable houses in the Temperate Zone.

Seeds of locally adapted varieties which are insect- or disease-resistant should be saved as they probably are not obtainable elsewhere. These may include USDA-34 sweet corn, tomato, cucumber, eggplant, pepper, and beans.

Crops which normally produce seed under most conditions in the West Indies and Hawaii (*13, p. 39*) are: Imperial 44 head lettuce, Black Seeded Simpson leaf lettuce, broccoli, beans, cowpeas, Chinese cabbage, soybeans, green and white mustards, corn, okra, eggplant, tomato, pepper, cucumber, melons, and some varieties of onions.[8] Vegetable crops which will seed under tropical conditions only with special technical handling are: Head cabbage, chard, carrot, celery, bulb onion, and beet.

SOIL PREPARATION

PLANT BEDS.—In tropical regions receiving heavy rainfall it is essential to provide good surface drainage of the soil. Raised beds (fig. 16 and 18) are commonly used to divert excess moisture when the soil is of medium to heavy texture. The beds may be 6 to 12 inches high, 3 to 6 feet wide, and any convenient length. Paths between beds are from 1½ to 2 feet in width. Raised beds have the advantages of being easy

[8] Sweetpotato will also produce seed under these conditions, but it is inferior to cuttings as a means of propagation.

FIGURE 18.—Growing seedlings for transplanting.

A, Sowing tomato seed in a flat of rich pulverized soil. The piece of wood is used for making furrows.

B, Outdoor raised seedbeds may be used for growing seedlings for transplanting. Note bamboo fence for protection against dogs and other animals.

C, Seedling tomatoes from beds in *B* have been transplanted about 6 inches apart in this nearby bed. These plants will be transplanted to the field when 6 to 8 inches tall.

D, Common method used by vegetable gardeners for growing Black Seeded Simpson leaf lettuce. Bed at right is used for germinating seed; seedlings are transplanted to other beds as shown at left. Bed at extreme right contains radishes and coriander seeded and growing together; radishes are pulled within 20 to 30 days, after which the coriander "takes over" and is harvested later.

E, Sheltered seedbed established at Toro Negro. This system was found necessary during heavy rainfall in summer to protect seed and plants from beating, washing rains.

to work, looking neat, and being less subject to trampling because their paths provide a place to walk and stand. Beds that are edged with boards, galvanized iron, or rocks generally have less trouble with weeds migrating from the paths. Bordered beds also are less subject to soil erosion and are easier to spade because less trampled.

During months of low rainfall raised beds have the disadvantage of drying faster and requiring more frequent watering. It is suggested that they not be used during this period unless they are already constructed, in which case use of mulch will help retard drying out of the soil.

Soil improvement.—The best soil for growing vegetables is a well-drained sandy loam high in organic matter. Such a soil is rarely available in the average backyard garden area. Nevertheless, it is frequently possible to grow satisfactory crops of vegetables by special treatments on heavy soils low in fertility. Soil improvement under these conditions may be effected by one or all of the following practices:

1. Loosening the soil for better drainage and aeration by adding large quantities of manure, compost, or sugarcane mill filter-press cake (cachaza), volcanic black sand, river or beach sand, or river silt.
2. Applying commercial fertilizers.
3. Applying agricultural limestone when the soil is very acid.
4. Judicious irrigation, avoiding excessive watering.
5. Improving surface drainage by using raised beds and grass-lined ditches constructed with very gradual grades.
6. Frequent cultivation when the soil is moist but not muddy.

When gardening on hillside terraces (fig. 8) large quantities of manure and compost may be required to improve the unproductive subsoil frequently met. This condition can be improved also by placing on the lower terrace the topsoil obtained from constructing the terrace immediately above. Gardens should not be planted on droughty, steep, unterraced hillsides where the topsoil has been largely washed away, leaving only the infertile subsoil. Rich lowland soils are best.

Manures.—Application of animal manure when available is a "must." Manure frequently makes the difference between an excellent and an average to poor crop. It not only is a source of plant nutrients but also aids root growth by making the soil more porous and crumbly and promoting good aeration and drainage. Quality of manure varies with the animal producing it, the feed the animal receives, and the age and care of the manure. As a rule, poultry manure is best, with that from the horse, cow, pig, and rabbit following in the order given. Manures in general are relatively high in nitrogen and potash but low in phosphorus. For this reason it is wise to apply commercial fertilizers with manure for such vegetables as tomatoes, beans, and peas. Manure applied alone to these crops may result in a highly vegetative condition of the tops with an average to poor crop of flowers, roots, or fruits. Manure applied alone to leafy vegetables, such as lettuce, chard, kale, mustard, and endive, may be satisfactory as the leaves are the part consumed. Poultry manure is relatively high in nitrogen and gives good response with the leafy crops. Fresh manure can be used provided it does not touch the plants. Filter-press cake (cachaza) from sugarcane mills is good for improving the soil provided it has been composted or well decomposed before application. Fresh cachaza applied to the vegetable garden may cause nitrogen deficiency or yellowing of the foliage. Application of fresh sawdust, straw, and similar materials will result in the same trouble. When these materials are used fresh, plenty of manure or commercial nitrogen fertilizer or both must be applied.

Strawy manure may contain weed seeds in varying quantities. If the manure is applied to the garden area a few weeks in advance, the

FIGURE 19.—A well-constructed backyard compost pile with a flat top and steep sides (*A*). The compost pile (*B*) should be kept moist and turned every 3 weeks for a 3-month period. Pile on extreme right has been turned and well mixed. (Courtesy Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A.)

seeds will germinate and most of the weeds can be destroyed while preparing the seedbed.

Composts and other materials.—The main benefit of compost is the improvement of aeration and drainage through the better physical condition of the soil thus created. Composts also help prevent baking and cracking of the soil after rains. A compost pile can be prepared by building up successive layers of such organic materials as lawn clippings, leaves, or tender hedge clippings with manure, then soil, and ammonium sulfate, ammonium nitrate (*57, pp. 16–17*), or sodium nitrate in the order named. Layers of leaves should be 6 inches thick. The fertilizer and soil are sprinkled on them, making the pile 3- to 6-feet high if necessary (fig. 19). If commercial nitrogen fertilizers are not available, complete fertilizers, such as 10-10-5, may be used instead. For each 100 pounds of leaf material, 10 pounds of superphosphate and 5 pounds of ammonium sulfate should be added. Weeds and diseased plants from the garden can be used for organic materials if properly composted and sufficiently aged. Well-prepared compost heaps will heat, thus destroying practically all weed and grass seeds and disease organisms. The compost heap should be sheltered from rains to reduce leaching. In dry regions a compost pit is preferred, but water should be added when dry plant materials are used.

The compost pile should be kept moist, but not soaked, all the time. The heap should be mixed by shifting with a shovel at 3-week intervals over a period of about 3 months.

Commercial fertilizers, amount and methods of application.—Under tropical conditions it is good practice to use commercial fertilizers with every planting, supplementing with manure when available. Most commercially mixed fertilizers contain the three important nutrients—nitrogen, phosphorus, and potassium—the percentage of each available nutrient being designated by a numerical formula. For example, a 100-pound sack of 10–10–5 fertilizer contains 10 pounds of nitrogen, 10 pounds of phosphorus, and 5 pounds of potassium, totaling 25 pounds of available plant nutrients. The remaining 75 pounds consist of inert ingredients or "fillers," such as sand or lime.

When using relatively low-analysis fertilizers at planting, such as 10-10-5, 6-9-5, or 5-10-10, the average application is about one medium handful[9] (3 to 4 tablespoonfuls) to 3 feet of row. For average-spaced rows (18 inches apart) this application corresponds to 800 to 1,000 pounds per acre. For concentrated fertilizers, such as 11-48 ammonium phosphate, slightly less than this quantity should be used at planting time.

For side dressings of fertilizer while the plants are growing, a medium handful of such fertilizers as ammonium sulfate, ammonium nitrate, sodium nitrate, and 11-48 ammonium phosphate should be applied to both sides of each 6 feet of row, 3 to 4 inches from the base of the plants. This corresponds to a side dressing of 300 to 400 pounds per acre at 18-inch row spacing. The fertilizer-application data in table 8 should be of value in calculating the amount needed in moderately large or commercial vegetable gardens.

[9] Amount of fertilizer in an average-size hand about half closed and held upright.

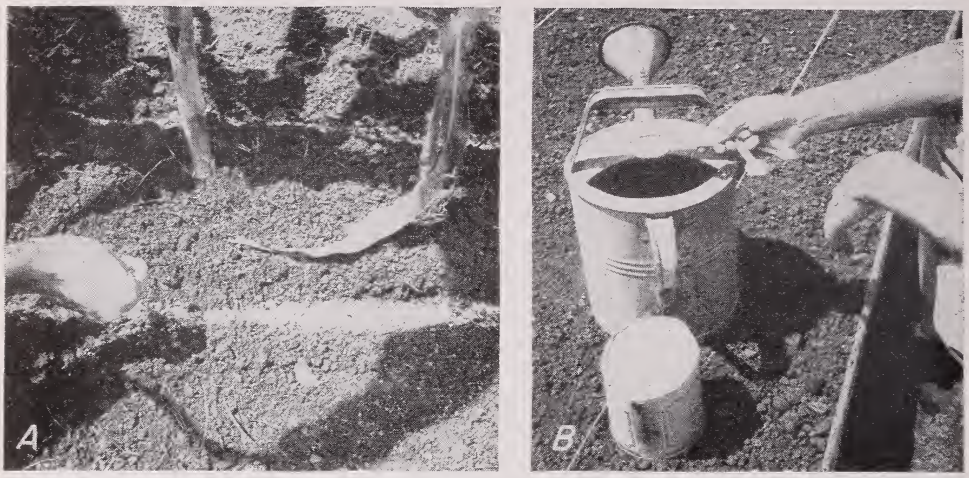


FIGURE 20.—Application of a side dressing of ammonium sulfate to corn when knee high (*A*). Complete fertilizer dissolved in water and sprinkled on the young seedlings induces more rapid and stronger growth (*B*).

TABLE 8.—*Quantity of fertilizer to be applied per 25 linear feet of row at various spacings between rows and various rates of application (13, p. 35)*

Distance between rows (inches)	Approximate quantity[1] of fertilizer per 25 feet of row on basis of—					
	200 pounds per acre	400 pounds per acre	600 pounds per acre	800 pounds per acre	1,000 pounds per acre	1,200 pounds per acre
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
12	0.12	0.25	0.35	0.50	0.60	0.75
18	.18	.37	.55	.75	.90	1.10
24	.25	.50	.75	1.00	1.25	1.50
30	.30	.62	.90	1.25	1.50	1.80
36	.37	.75	1.10	1.50	1.80	2.20
42	.43	.85	1.25	1.75	2.10	2.50
48	.50	1.00	1.50	2.00	2.40	3.00

[1] Roughly, 6 to 9 medium handfuls of fertilizer will weigh 1 pound. This will vary, of course, with hand size and the weight of the fertilizer.

Methods of applying fertilizer are shown in figures 16 and 20. It is good practice to apply a complete fertilizer with manure at planting time and supplement this with a side dressing of commercial fertilizer, such as ammonium sulfate, after the plants have become well established. If fertilizers are available only in 200-pound bags, which may be too much for a single gardener, neighboring gardeners can buy a bag together.

As nitrogen dissolves easily in rain or irrigation water and goes into the soil rapidly, it always can be applied as a surface side dressing. Potash and particularly phosphate dissolve much more slowly and should be applied in 3-inch furrows and covered with soil. The furrows

are run on either side of the row and not closer than 2 inches from the plants. When the soil is heavy, side dressings by furrow are particularly recommended; if sandy, side dressings of all fertilizers can be applied on the soil surface. Fertilizer elements will not be readily available to the roots until after a rain or an irrigation. By no means should the fertilizers come in contact with the seed, leaves, or plant roots; burning and killing will result.

Relatively little work has been done on the so-called "minor" elements —manganese, boron, zinc, copper, iron, and possibly others, such as magnesium and molybdenum—in vegetable crop production in the Tropics. There is reason to believe that these minor elements may be factors limiting growth under some tropical conditions, particularly where leaching from heavy rainfall may be pronounced and where excessive amounts of some nutrients, such as water-soluble manganese, may create deficiencies of others, such as iron (*18*), or the reverse manganese-iron relationship may exist (*47*).

During the vegetable trials here reported, symptoms which closely correspond to minor-element deficiencies have been noted from time to time (*46*). In Michigan (*24, p. 19*) manganese and boron deficiencies are reported most likely in alkaline soils, particularly with such vegetables as red beet, turnip, rutabaga, head lettuce, cabbage, cauliflower, and spinach. Pronounced symptoms of boron deficiency are black corky areas in the beet flesh, rough cankers on the outside of the beet, blackened small center leaves in head lettuce, cabbage, and cauliflower, and small deformed center leaves on spinach. Manganese deficiency is easily seen on beet leaves as a fading of color between the green veins. Minor element fertilizers, when needed, can be thoroughly mixed with sand or the main garden fertilizer, as even application of small concentrated quantities is difficult. Boron as common borax is generally applied at the rate of 6 ounces per 1,000 square feet and manganese at the rate of 1 pound manganese sulfate per 1,000 square feet. When boron-susceptible vegetables are interspersed with others less likely to show these deficiencies, it is wise to use only 3 ounces of borax per 1,000 square feet for the entire garden area. Some vegetables are injured by borax if applied at the higher rate.

Copper is not likely to be limiting where copper sprays such as bordeaux mixture are used. Zinc deficiency has been described as of economic importance only on a few vegetables growing under unusual soil conditions in Florida and California (*46, pp. 168–169*). Foliar symptoms of zinc deficiency are the same for bean, tomato, and squash. Some leaves are abnormally small and mottled with dead areas; others are uniformly chlorotic. A pinch of zinc sulfate in 10 gallons of water sprayed over the plants should counteract zinc deficiency. Iron deficiency also results in chlorosis of the tip leaves and is most likely to appear on alkaline soils. It can be counteracted with iron sulfate—a pinch of the sulfate in 10 gallons of water. If supposedly minor-element deficiency symptoms are persistent and pronounced it may be desirable to check each minor element separately on neighboring plants to determine which one, if any, gives the most striking response.

Lime.—Most vegetables grow best when the pH of the soil is between 5.5 and 6.5 (somewhat acid to slightly acid). Such vegetables as leaf lettuce do not do well in alkaline soil. Under most garden conditions in the Tropics lime is not necessary for vegetables. If there is some

doubt, particularly when the pH is below 5.5, the gardener can apply lime to a small area at the rate of 10 to 15 pounds of air-slaked (hydrated) lime per 100 square feet of area and observe any improvement in growth. If it has been found that lime is needed, the form available should be broadcast on the surface in the quantity shown in table 9 and spaded to the depth of the spade some weeks in advance of planting.

TABLE 9.—*Approximate quantity of liming materials required to reduce acidity in garden soil*

Material[1]	Quantity per 1,000 square feet of garden having initial pH of [2]—		
	Below 5.0 (very acid)	5.0 to 5.5 (acid)	5.5 to 6.0 (moderately acid)
Ground limestone----------pounds---	100	75	50
Limestone meal----------do-----	100	75	50
Hydrated lime----------do-----	75	50	35
Marl, 50 per cent $CaCO_3$----------bushels---	6	4	2
Marl, 90 percent $CaCO_3$----------do-----	3	2	1
Sugar factory refuse----------do-----	3	2	1

[1] Other refuse-lime materials, such as water softener lime, are equally good *provided they contain no toxic substances.*

[2] Local experiment stations usually can make soil analyses. Send ½ pint sample.

PLANTING SEED

DIRECT SEEDING IN GARDEN.—Quantity of seed, row spacings, depth to plant, estimated yields, and time required for maturity are shown in table 10. The corner of a hoe can be used for making the deeper furrows for bean and corn seed; the end of the hoe handle (fig. 21), for making shallow furrows for turnip and other small seeds (fig. 16, *D*). The square end of a 1-by-4-inch stake can be used for making a shallow broad furrow, often good for wide distribution of seeds in the row for such crops as beet, radish, turnip, lettuce, mustard, and carrot. A cord should be stretched between two stakes to insure straight rows that look neat and also facilitate cultivation and prevent loss or damage of plants by machinery. A stake bearing the vegetable name and date of planting should be set at the end of each row.

In general, small seeds are planted about ½-inch deep; big seeds, such as corn, 1 to 1½ inches deep (fig. 16). Seed should be planted slightly deeper in sandy than in clay soil. In fact, it is best to plant somewhat more shallow than recommended in table 10, *provided* special care is taken to maintain even and plentiful, but not excessive, soil moisture around the seed. This can be done by sprinkling a thin layer of sand, cachaza (filter-press cake from cane mills), or, preferably, well-rotted manure over the seeded area (fig. 16, *H*), or by using a thin mulch (1-inch deep) of lawn clippings or similar fine material. After the seeds have germinated the mulch should be pulled back slightly to allow them to emerge freely.

FIGURE 21.—Useful tools for preparing, planting, and maintaining a garden. In man's right hand are a claw weeder, trowel, measuring spoons, and a machete. Under his right arm are a sprinkling nozzle for the garden hose, a garden line with stakes, and large labeling stakes. Over his left shoulder are a rake, hoe, spading fork, and a sprinkling can.

Under tropical conditions, where cutworms, mole crickets (changas), damping-off, or poor seed germination tend to interfere with the early stages of growth, it is wise to plant about twice the quantity of seed specified in table 10. This is particularly true for small-seed crops, such as lettuce and carrot. Planting too many seeds is poor practice as it will entail hand thinning later in the season and also closely planted seed-

TABLE 10.—*Spacing, planting depth, seed requirements, time required for maturity, and estimated yield of vegetables in the Tropics*

Crop	Spacing of plants[1]		Depth to plant seed	Seeds per foot of row[2]	Quantity of seed or plants per 25-ft. row	Time required to reach maturity[3]	Estimated yield per 25-ft. row
	In row	Between rows					
	Inches	*Inches*	*Inches*	*Number*		*Days*	
Asparagus	18–24	36	¾–1		12–16 plants	730	2 pounds.
Bean, green bush	3–6	18–24	¾–1½	4–6	4 ounces	42–56	12 pounds.
Bean, lima bush	6–8	18–24	¾–1½	3–4	3 ounces	60–80	[5]6 pounds.
Beet	2–3	18–24	½–1	12–15	½ ounce	65–100	20 pounds.
Broccoli	15–18	18–30	½		12–15 plants	65–85	8 pounds.
Brussels sprouts	15–24	18–30	½		12–15 plants	120	2 pounds.
Cabbage	12–24	18–24	½		12–25 plants	70–100	12–25 heads.
Cabbage, Chinese	3–16	15–24	½	8–10	1 packet	95–100	18–30 heads.
Carrot	2–3	15–18	½	30–40	¼ ounce	74–108	20 pounds.
Cauliflower	15–18	24–30	½		16–20 plants	56–118	16–20 heads.
Celery	6–12	15–24	⅓–⅜		25–50 plants	110–150	25–50 heads.
Chard, Swiss	6–12	15–24	¾–1	4–6	1 packet	60–75	25 pounds.
Collard	15–18	18–24	½		12–15 plants	80–100	30 pounds.
Corn, sweet	10–15	24–36	2–3	2–3	2 ounces	90–120	30 ears.
Cucumber	36–48	48–60	½		⅛ ounce	56–65	15 pounds.
Eggplant	24–36	30–36	½		8–12 plants	89–132	50 pounds.
Endive	12–15	15–18	½		⅛ ounce	56–92	12 pounds.
Kale	18–24	12–15	½–1		do	52–91	15 pounds.
Kohlrabi	18–24	3–6	½–1	12–15	1 packet	50–98	Do.
Leek	15–18	2–3	½		do	132–160	
Lettuce, leaf	8–12	6–12	½–¾	12–24	do	46–70	25–30 bunches.
Mustard	1–2	18–24	½	20–30	do	48–59	25 pounds.
Okra	12–15	36–48	½	4–6	½ ounce	55–60	30–40 pounds.
Onion, green	4–6	18–24	½	20–30	1 packet	120	10 pounds.
Parsley	4–6	12–18	½	20–30	do	75	5 pounds.
Parsnip	4–5	15–18	½	12–15	do	139	24 pounds.

Pea	2–6	13–24	1–1½	4–6	2–4 ounces	57–78	5 pounds.
Pepper	12–18	18–24	½		16–25 plants	96–112	15 pounds.
Potato	12–15	18–24	3–4		[4]20–25 seed pieces	75–100	20 pounds.
Pumpkin	72–84	72–84	½		½ ounce	112	30–40 pounds.
Radish	1–2	12–18	½	30–40	do	23–30	20 dozen.
Rhubarb	24–36	24–36	½		12–16 plants	132	
Rutabaga	3–6	18–24	½	20–30	1 packet	72	15 pounds.
Spinach, New Zealand	12–15	18–24	½	6–12	2 ounces	63–76	10 pounds.
Squash	36–48	36–48	1–1½		1 ounce	47–89	25–40 pounds.
Tomato	24–48	36–48	½		6–12 plants	54–90	50 pounds.
Turnip	3–6	15–24	1–1½	20–30	1 packet	70–75	10 pounds.
Watermelon	36–48	48–72	1–2		⅛ ounce	100	100 pounds.

[1] Wider spacing may be desirable where mechanical equipment is used for planting, cultivating, or harvesting.

[2] More seed should be planted if germination tests show low seed viability.

[3] Time is given as the approximate number of days to produce crop from planting seed in the garden or from transplanting plants to the garden.

[4] Each seed piece should weigh 2–3 ounces; thin slices with buds should not be used.

[5] Shelled.

lings are more susceptible to damping-off disease. If the percentage germination is high for large-seeded vegetables, such as pea and corn, only slightly more seed than required should be planted.

Chard and beet seeds tend to produce two or more plants from a single seed, in which case the planting rate should be the same as that recommended in the table. Also, chard plants require wide spacing in the row for best development and so should not be planted thickly.

THINNING SEEDLINGS.—Most seedlings should be thinned at the three- to four-leaf stage. By no means should thinning be delayed until the seedlings are badly crowded, spindly, and competing with each other. Thinning of beet and carrot where the seedlings are delicate must be delayed. Excessive early removal of these seedlings may result in poor stands. Plants likely to receive good fertility and water supply can be left closer together than those that may receive limited quantities. It is best at first to attempt to space the plants approximately as indicated in table 10. By observing and experimenting the gardener may later decide to leave the plants closer or space them wider, depending upon local growing conditions. Close spacing will delay maturity of root crops, but this may be desirable to spread the harvest over a longer period.

GROWING TRANSPLANTS.—Some vegetables can be grown more easily and successfully by planting the seed in flats (fig. 18) or in special seedbeds, after which they are transplanted to pots or another seedbed before being set out in the field. The main reasons for transplanting some vegetables are to simplify irrigation, weeding, and control of insects and diseases in the seedling stage, and to utilize the garden area more efficiently.

Where transplants are available from a local professional gardener, it may be better to buy the plants ready for immediate transplanting to the field than to grow them at home.

Vegetables that benefit from transplanting are broccoli, cauliflower, celery, eggplant, head cabbage, kohlrabi, lettuce, New Zealand spinach, onion, pepper, and tomato.

Vegetables that transplant most easily are broccoli, celery, eggplant, head cabbage, lettuce, onion, parsley, sweetpotato, and tomato. More difficult to transplant are beet, chard, chayote, Chinese cabbage, spoon cabbage, and New Zealand spinach. Vegetables that transplant poorly unless special care is given are bean, carrot, corn, cowpea, mustard, okra, pea, potato, radish, soybean, and turnip. With extreme care, however, almost any vegetable can be transplanted successfully.

A good loose fertile top soil free from nematodes is most desirable for growing seedlings in pots, flats, or raised seedbeds. Nematodes, diseases, and insects can be killed by placing the soil in a shallow pan and baking in an oven for 2 hours at about 180°F., or by pouring boiling water over the soil at the rate of 1 gallon of water to 1 gallon of soil. Drenching the soil with 40-percent formaldehyde at the rate of 1 part in 50 parts of water is effective for soil sterilization. Chloropicrin (tear gas) and D-D (for nematodes and insects only) also can be used according to the manufacturer's recommendation. Soil treated by these three chemicals, however, cannot be used for 10 days to 2 weeks.

In the use of these insecticides, extraordinary caution should be practiced by the user. Please read cautions on pages 31 and 98 before attempting to handle, mix, or apply these chemicals.

Heavy soil can be improved by mixing it with one-third well-rotted manure and one-third sand. Sandy loam can be improved by mixing 1 part compost or manure to 2 parts of soil. Immediately after planting the seed the soil should be sprinkled until moderately wet. Good drainage in the bottom of flats, cans, and pots is important. Drainage can be improved by placing a layer of stones or broken pieces of pots in the bottom of the containers. Seedlings will grow well in cans or pots, provided they receive regular and adequate watering; infrequent watering is usually the main reason for their failure under these conditions.

Seedlings grown in flats or outdoor seedbeds should be transplanted at the 3- to 4-leaf stage to other flats or to another seedbed in the field (fig. 18), spacing them 4 to 6 inches apart. When 6 to 8 inches high they can be transplanted to the field. The soil about the roots of seedlings in flats or seedbeds should first be cut into squares with a table knife. These squares are carefully handled while transplanting to avoid loss of roots and to retain as much soil around the roots as possible. Wetting the soil before transplanting helps hold it together. Seedlings of head cabbage, cauliflower, kohlrabi, onion, eggplant, and pepper are set slightly deeper in the field than their depth in the pots or seedbeds. Soil is placed about the roots until the hole is half full and then firmed, after which one or two cups of water are poured into the hole and allowed to settle. Finally, the hole is filled with loose pulverized top soil. If no rains fall immediately after transplanting, the plants should be irrigated daily, or when necessary, until well established.

Transplanting is best done in late afternoon or on a cloudy day. Wilting during the next day can be reduced by shading with leafy branches of *Hibiscus* or other vegetation stuck in the ground, or by placing paper caps, north side open, over each plant in the form of a wigwam, held up by a small stick. Also, a long cloth held up V-shaped by stakes and a wire or string immediately above the plants may be used. Daily care is necessary for satisfactory seedling progress.

Home-made paper cups for growing transplants can be constructed as follows:

Cut entire newspaper sheets into strips 6 inches wide, place a pint milk can or bottle near one edge of the paper strip, and roll the paper up with the container. Leave about 2½ inches of the paper strip below the bottom of the container, fold this paper tightly against the bottom, and remove the container, thus making a temporary cup. Place close together in a flat when filled with soil.

Good practice for keeping seedlings growing rapidly in the seedbed is to sprinkle them with a fertilizer solution once a week (fig. 20). A solution of 3 to 4 level tablespoonfuls of a complete fertilizer, such as 10-10-5, in a 3-gallon sprinkler can serves this purpose and also can be used in place of tap water while transplanting seedlings to the field, 1 pint of solution in each hole being sufficient.

Damping-off disease.—Damping-off is a common disease of young plants in seedbeds. It is identified by a water-soaked constriction of the stem just above the soil surface which makes the top bend over. Pretreatment of the soil with chloropicrin, formaldehyde, boiling water, or baking in an oven is recommended for this disease (p. 44). If plants begin to damp-off in the seedbed, they should be sprinkled immediately with "Semesan"[10] or copper oxide, both obtainable at seed supply

[10] Extreme caution should be taken to keep all poisonous materials out of reach of children, house pets, and livestock. Surplus treated seed should be destroyed.

houses. Semesan is applied at the rate of 1 tablespoonful per gallon, using 1 to 1½ quarts per 10 square feet of area. Copper oxide is applied at the rate of 1½ teaspoonfuls per gallon of water, thoroughly drenching the seedlings and soil surface.

Semesan has been found best for seedlings of broccoli, cabbage, okra, turnip, and radish, whereas copper oxide is preferred on celery, tomato, and lettuce. Either of the two chemicals can be used on beet, carrot, chard, eggplant, green bean, kohlrabi, and pepper.

A further recommended preventive for damping-off is to treat the seeds of the foregoing vegetables with Semesan or copper oxide before planting. A half teaspoonful of either of these chemicals is placed in a small bottle or can with the seed and the container covered tightly and shaken thoroughly for about a minute. Excess powder in the bottom of the container can be saved and used again. Seed covered with the dust should be planted immediately after treatment (p. 101).

CULTURE OF INDIVIDUAL CROPS

Artichoke

JERUSALEM-ARTICHOKE.—This herbaceous perennial can be grown widely in the Tropics, particularly in India. The oblong potatolike tubers are the edible portion (*62, p. 355*). The Jerusalem-artichoke tolerates poor soils better than most crops, but does not thrive under excessive rainfall and wet soil conditions. Production is best in rich, moist lowland areas receiving less than 50 inches of annual rainfall.

The seed tubers are planted about the time new shoots appear from the base of old plants, which is several weeks in advance of the rainy season. The tubers are spaced 1 foot apart in rows 2½ feet apart and cultivated and watered until established. Once established the Jerusalem-artichoke competes well with weeds. To promote good top and root development the flowers should be removed as they appear. Plants usually grow about 3 to 4 feet high in the Tropics; in the Temperate Zone they may reach 6 to 10 feet.

The tubers require 2½ to 3 months to reach good size. All can be harvested at one time, or those on the outside of the row can be harvested first before they harden. Some tubers may be left in the ground for seed over the dry season, or they may be lifted and stored in dry sand in an unglazed earthenware pot.

GLOBE ARTICHOKE.—The Globe artichoke is more difficult to grow in the Tropics than the Jerusalem-artichoke. The tender unexpanded round or broadly cone-shaped flower heads are cooked for eating. The large deep-cut glaucous leaves make it a handsome ornamental.

The Globe artichoke grows best in relatively dry districts at altitudes above 4,000 feet (*26, pp. 303–304*). At low altitudes flower heads may fail to form because of higher temperatures. It is propagated by seed or, preferably, by suckers. The seeds are planted in close rows in a flat or seedbed. The small seedlings at the 3-leaf stage are transplanted 6 inches apart in another seedbed. When 4 to 6 inches high they are set in the garden at a distance of 3 feet apart in rows 4 feet apart. The plants grow best in rich moist soil near streams. The heads should be ready to harvest within about 8 months after planting. There are green and purple varieties.

INSECTS AND DISEASES.— No records of insect pests of any consequence on either the Jerusalem- or Globe artichoke in the Tropics are available. Where mole crickets are present they may attack the tubers of the Jerusalem type.

Asparagus

Yields of asparagus and size of spears at this station have not been comparable with those in the Temperate Zone of the United States. The home gardener in the Tropics who is accustomed to eating fresh asparagus in the Temperate Zone may enjoy maintaining a few plants, even though the yields are moderate to low.

Asparagus is grown from seed under tropical conditions because roots are difficult to ship. The seed is sown in rows in a seedbed and grown for several months until the seedlings are about a foot high, when

FIGURE 22.—Commercial vegetables grown by Puerto Rico Agricultural Company near Bayamón: Bunching onions (*A*), California Wonder peppers (*B*), Mary Washington asparagus (*C*), Rosita eggplant (*D*), Calabrese broccoli (*E*).

they are transplanted to a well-drained sandy loam soil high in organic matter. The seedlings are set in the bottom of a ditch about 14 inches wide and 6 inches deep and well-rotted manure is added from time to time until the ditch is completely full. This crop responds well to large applications of manure. Nitrogen and phosphorus applied as ammonium phosphate (16–20) are valuable supplements to manure and can be applied either before or after the cutting season, which may begin within about 2 years after transplanting in the field.

To induce dormancy water should be withheld for 2 or 3 months at the beginning of the cool dry season. The tops are then cut off and the area hoed or disked and irrigated regularly. Spears may be harvested when 6 to 8 inches long over a period of 3 to 6 weeks, beginning in January. The cut is made about an inch below ground. Lower ends of harvested spears should be placed in a pan of water under refrigeration to maintain quality until cooked

After harvest the tops should be allowed to develop for several months to store food in the fleshy roots for the next crop (fig. 22, *C*). Because no rest period is induced by a cold winter under tropical conditions, asparagus tends to lose vigor in a few years. In dry regions an artificial rest period may be provided by withholding water at the beginning of cool dry weather.

INSECTS AND DISEASES.—No diseases have been observed. A beetle caused stem and leaf injury and damaged some of the spears at Toro Negro.

Beans

LIMA BEANS.—Results with lima beans in Puerto Rico have been spotty. Pod borers and leafhoppers appear to be the principal limiting factors. Insect damage is greatest during the warm moist season until about October, when fair sets of pods have been noted on both cultivated and native varieties (*35, 1937, p. 59*). Summer temperature may be an important limiting factor, for temperatures above 80°F. are generally known to reduce set.

Good yields of 30 varieties of small- and large-seed pole and bush lima varieties were obtained by Bailey (*35, 1937, p. 62*) at Mayagüez when the crop was planted the latter part of December. Best yielders were the large-seed pole varieties, including Early Leviathan, Ford Mammoth, and Burpee Sunnybrook, which produced, respectively, 533, 524, and 512 bushels of shell beans per acre, about 54 percent being hulls. The glossy foliage of the small-seed varieties was more susceptible to leafhoppers, which caused curling, discoloring, and dropping of the leaves. In the vegetable trial gardens at Mayagüez in 1945 the Henderson variety planted in January was severely injured by leafhoppers, whereas the Fordhook was relatively resistant (fig. 23, *D*).

Good yields of lima beans have been reported in Hawaii for large-seed varieties, such as Fordhook Bush, Fordhook Pole, and King of the Garden (*13, pp. 78–79*). Small-seed bush varieties, such as Henderson, Baby Potato, and Hopi, also performed well. Although a factor in Hawaii, the pod borer is effectively controlled by dusting or spraying with cryolite. At Mayagüez fair yields with Fordhook Bush were obtained in summer when the crop was sprayed for leafhoppers with DDT. However, DDT was ineffective against pod borers (*35, 1947*).

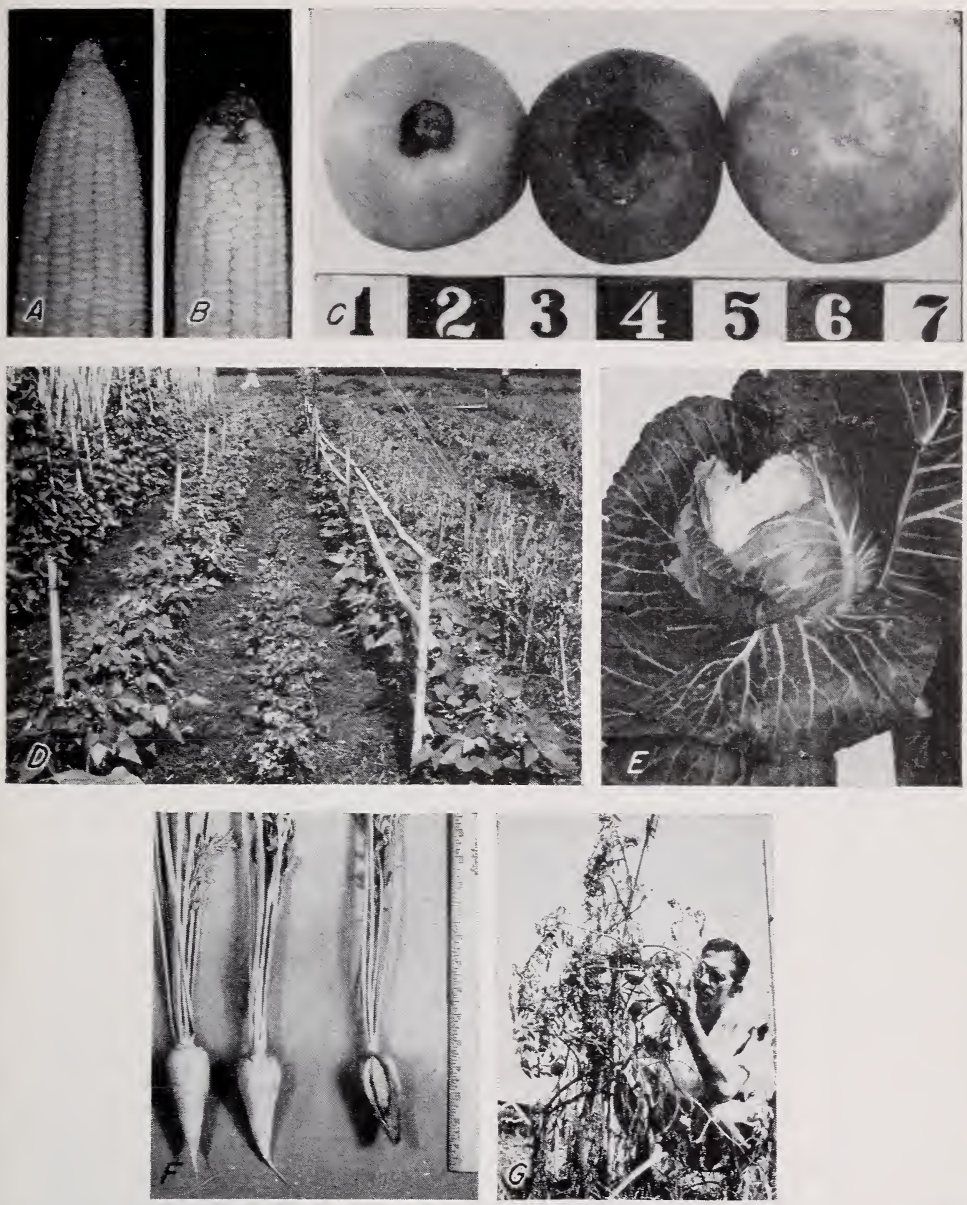


FIGURE 23.—*A*, Ear of USDA–34 sweet corn previously treated with oil and pyrethrum mixture (*4, p. 14*), free from silk fly injury. *B*, Typical injury by silk fly on untreated ears. *C*, Two tomatoes on left show progressive degrees of blossom-end rot, physiological disease caused by improper moisture supply to the fruit; right tomato shows "halo" spotting presumably caused by a nutritional disorder. *D*, Bush lima beans showing relative resistance to leafhopper damage at Mayagüez; left to right, Imperial Fordhook, Henderson, and Fordhook. *E*, Heads of Golden Acre cabbage tend to crack open if a dry period is followed by an irrigation or heavy rainfall. *F*, Danvers Half Long carrots showing splitting caused by wet weather following a drought; rotting usually follows splitting. *G*, Late blight frequently defoliates tomato plants grown in Puerto Rico during the rainy season.

The law in some places prohibits the use of DDT as a spray for vegetables for human consumption or on feed which will be eaten by milk or beef cattle. See pp. 114-115 for the use of DDT as a contact insecticide.

Thus it appears that if the lima bean is planted in the lowland home garden it should be planted during the midcool season and sprayed regularly to control insects. Cultural recommendations for lima beans are similar to those for snap beans.

The lima bean can be harvested over a longer period than green beans. Under good conditions vines of King of the Garden will bear for several years. For best cooking quality they should be harvested before the beans reach the white stage. Only experience will indicate the best stage for picking.

SNAP BEANS.—Green beans can be grown throughout the year at low to moderately high altitudes (65° to 80°F.), but best production is obtained in the winter and spring when rainfall is not excessive. Fair crops of bush varieties have been obtained, however, in summer at both Maricao (2,600 feet) and Toro Negro (3,300 feet) in spite of rains. The beating rains reduce the crop by aggravating diseases, by interfering with pollination, and perhaps by knocking off some of the blossoms.

Logan, Tendergreen, Black Valentine, Giant, Stringless Green, pod, the golden- or waxy-podded varieties, and Bountiful have performed well from October to May, and also in summer when an attempt was made to control the leafhopper, a serious pest in many tropical regions. Bountiful is especially susceptible to leafhopper damage. The Agricultural Experiment Station of the University of Puerto Rico has developed a number of definitely improved bush bean varieties highly resistant to local insects and diseases, the best of which include Nos. 1329, 1395, 1435, and 1632 (fig. 14, *C*). Beans of these varieties can be used as "snap" green beans if harvested when the pods are young, or they may be grown for dry beans. Yields of these varieties have amounted to 304 to 374 pounds of shelled dry beans per acre (*36*, *1945–46*). Nos. 1329, 1395, and 1435 are of superior cooking quality. Rust Resistant Kentucky Wonder is the only pole variety showing acceptable yields.

Bean seeds should be planted about 1½ inches deep and spaced 3 to 4 inches apart in the row for bush beans and 12 to 18 inches for pole varieties. A heavy application of well-rotted barnyard manure should be mixed with the soil during seedbed preparation and a complete fertilizer high in phosphorus added in furrows on either side of the seed furrow at planting time (fig. 16, *F*). For best production beans should be kept growing vigorously to develop a good-size plant before flowering begins. A side dressing of ammonium sulfate is recommended when the first pods are setting; fertilization at this time should prolong the harvesting season and increase the size of the pods.

The pods should be harvested while young and tender and before they become "lumpy," which is an indication of maturity and toughness. Picking at 3- to 4-day intervals keeps the plants producing freely; vines are weakened by allowing pods to hang on to maturity. It is best to harvest beans while the plants are dry to avoid spreading pod and leaf diseases. Harvested pods should be placed under refrigeration immediately to maintain good cooking quality.

Bush beans have a harvest period lasting for 2 to 3 weeks; pole varieties may bear an additional 2 to 3 weeks. Bush varieties bear a week or so before pole varieties. Irrigation is necessary during dry periods, particularly during the harvest season.

Although bush beans are easier to plant and manage in home gardens, pole varieties usually bear better per unit of ground and do not need to be planted so frequently. Tripods of bamboo poles are good supports for pole varieties.

INSECTS AND DISEASES (LIMA AND GREEN BEANS).—Most troublesome bean insects in Puerto Rico are the leafhoppers and pod borers. Leaf beetles, mites, aphids, thrips, lacebugs, and leaf tiers may also cause damage. Dry beans in storage may become infested with bean weevils (*Bruchus* spp.). Powdery mildew, scab (Elsinoe), brown rot, mosaic, rust, anthracnose, and leaf spot (Cercospora and Isarropsis) may be destructive diseases.

Beet

Beets are a valuable crop in the garden not only for the fleshy roots but also for the tops which can be used as greens. Beets do best under cool conditions. Good results were obtained throughout the year at Toro Negro, P. R., at 3,300 feet. At 2,600 feet and at sea level, the best crops were grown during the cool season. Beets can be grown during the summer at low elevations, but their size, quality, and color may be somewhat inferior.

Special attention must be given to the preparation of a fine seedbed to ensure good germination and early growth. Manure and complete fertilizers should be incorporated with the soil before planting. The addition of 300 to 500 pounds per acre of common salt (sodium chloride), as previously used at this station (*14, p. 24*), often doubled root size at Toro Negro and Mayagüez (fig. 24, *G*). Beets do not perform well on very acid soil. Lime should be applied to bring the pH to around 6.0 to 6.5.

The seed should be distributed over a row 4 inches wide. Germination can be improved during dry weather by covering the seed row with a layer of rotted manure (fig. 16, *H*), paper, or cloth to conserve moisture. Soil should be kept moist by regular irrigation. The seed balls frequently contain more than one seed, so that two or three plants may be expected to develop from a single ball. As the plants develop they should be thinned to about 3 inches apart in the row; the thinnings can be used for greens. Beets should be harvested before they become overmature, tough, and woody.

INSECTS AND DISEASES.—Most troublesome insects are a cutworm, the beet webworms (fig. 25, *A*), and other minor insects which are prevalent during the warm season. A glistening golden beetle sometimes may be serious enough to prevent crop development entirely. Damping-off disease may be serious when the plants are young. Leaf spot causes moderate damage during the rainy season.

Broccoli

Broccoli grows well during the cool season at all elevations in Puerto Rico; at high elevations it grows well at all seasons except the warmest heavy-rainfall period. Plantings which were made or which matured during the warm rainy months failed at both Maricao and Toro Negro,

FIGURE 24.—*A*, Field of sweetpotatoes (native variety) near Arecibo.

B, "Apio del País" (*Arracacia xanthorrhiza* Bancroft) near Yauco showing tops and edible roots.

C, Field of potatoes at Puerto Rico Agricultural Experiment Substation, Isabela.

D, Field of Danvers Half Long carrots at Borinquen Army Air Base near Aguadilla.

E, Hollow Crown parsnips grown at Toro Negro.

F, Seven varieties of radishes grown successfully at Mayagüez. Early Scarlet Button was best in quality and attractiveness.

G, Detroit Dark Red beet from Mayagüez (two beets on the right are from field receiving 500 pounds per acre of table salt (sodium chloride)); beets on the left received no salt.

FIGURE 25.—Damage caused by two troublesome pests of greens.

A, The southern beet webworm (*Pachyzancla bipunctalis* (F.)) on chard, also attacks leaves of beet, other vegetables, and weeds.

B, Larvae of the diamondback moth (*Plutella maculipennis* (Curt.)) on collard; this is perhaps the most serious and difficult pest to control on plants of the cabbage family in the Tropics. Under side of leaves is first riddled as shown and then heads are perforated. (*A* reduced to about ¼; *B* ⅔ natural size.)

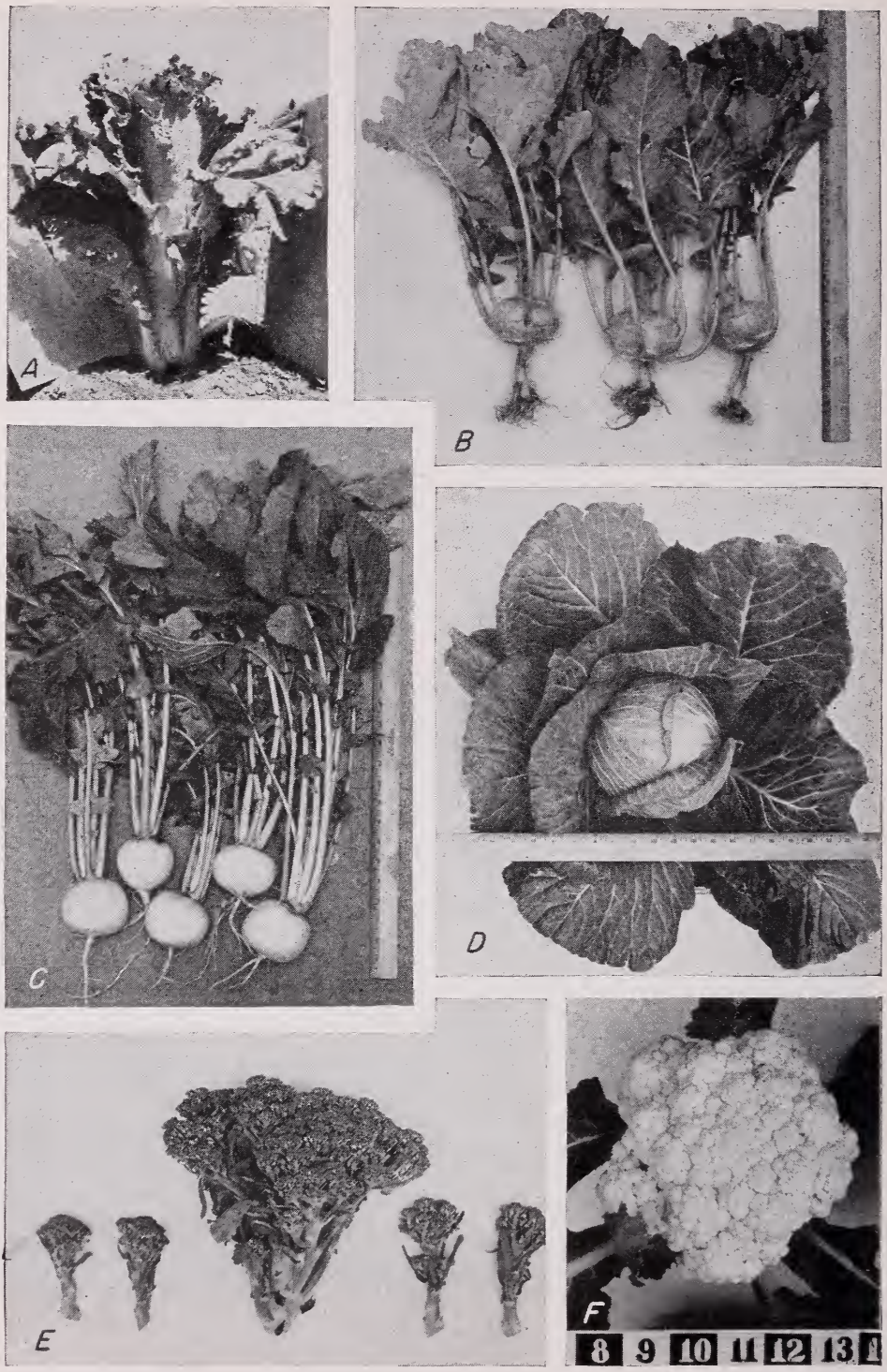


FIGURE 26.—Most cole crops produce good yields in winter at sea level and throughout the year at high altitudes:

A, Chi-Hi-Li Chinese cabbage at Mayagüez.
B, Early White Vienna kohlrabi from Toro Negro.
C, Purple Top White Globe turnips from Toro Negro.
D, Head of Golden Acre cabbage grown at Mayagüez.
E, Large center head and small side shoots of Calabrese broccoli from Maricao.
F, Small head of Indian (Early Patna) cauliflower grown at Mayagüez in winter

but plantings made during the cool months and maturing during the early spring rains gave excellent results, particularly at Maricao. Italian green sprouting Calabrese variety has performed well under Puerto Rican conditions; Propageno variety, in addition, is recommended in Hawaii.

Broccoli is not hard to grow. It is more productive and withstands heat and dry conditions better than its close relative cauliflower. The large edible center cluster of buds develops first and is harvested just before the yellow flowers begin to open (fig. 26, *E*). About the time the center head is harvested it is advisable to give a side dressing of complete fertilizer, or 16–20 ammonium phosphate. This stimulates development of the edible side shoots, which may be harvested over a period of 2 months. As the stems below the flower clusters are highly nutritious, from 4 to 6 inches should be cut with the main flower head and 2 to 4 inches with the side shoots. These stems should be split before cooking so that they will cook as fast as the flowers. The top of the center stem may rot after harvest if rainfall is abundant or overhead irrigation is used. Rotting may be prevented by placing a moisture-proof paper cap over the cut surface on the stalk or by making a slanting cut at harvest.

Insects and diseases.—Same as for cabbage.

Brussels Sprouts

Brussels sprouts require very high altitudes and a cool temperature (55° to 65°F.). At 3,000 feet in Puerto Rico, only a small percentage of the plants formed small cabbagelike heads in the leaf axils and these were "strong" in flavor.

At altitudes where this crop can be grown, the seed may be planted directly in the field, like Chinese cabbage, or the seedlings can be transplanted from seedbeds, like cabbage. The small budlike heads can be harvested when firm and 1 to 2 inches in diameter. Some of the lower leaves may be removed if the buds become crowded. This crop should withstand moderate freezes at very high altitudes in the Tropics (*37, p. 299*). The buds are cooked like cabbage.

Cabbage

Head cabbage.—Head cabbage can be grown throughout the year in Puerto Rico, but the largest and heaviest heads are produced during the cool winter and early spring months. Most standard varieties produce satisfactorily, but Golden Acre (fig. 26, *D*), Succession, All Seasons, and Copenhagen Market have produced the largest percentage of good heads under trial conditions. At Mayagüez and near Aguadilla, heads weighing from 2 to 4 pounds were produced in the warm season and heads weighing from 4 to 6 pounds in cool months. At Toro Negro during the cool season heads weighing from 7 to 9 pounds were not uncommon.

Aside from the usual preparation of the soil with manure and complete fertilizer before planting, it is wise to apply a side dressing of ammonium sulfate or a complete fertilizer shortly after the heads begin to form. A side dressing of nitrogen is particularly important if the cabbage begins to head while still small or the leaves show yellowing. One tablespoonful per plant should be adequate.

Although the early-maturing Golden Acre performed satisfactorily in Puerto Rico, it was found advisable to keep the soil moisture relatively uniform by regular irrigation during dry periods. Heads of this variety tend to crack open (fig. 23, *E*) when a dry period is followed by an irrigation or by heavy rainfall. A combination planting of Golden Acre for early maturity and Succession or Copenhagen Market for later harvest is suggested. Varieties having small heads, such as Golden Acre, should be spaced 12 inches apart in the row; large varieties, such as Copenhagen Market and Succession, should be spaced about 18 inches apart.

It is highly important to keep the young seedlings stocky and moderately vigorous before and after transplanting. A vigorous start with these seedlings makes a tremendous difference in subsequent size of the heads. Seedlings stunted by drought, low fertility, or insects will give mediocre to poor yields.

INSECTS AND DISEASES.—Worst insect pests are larvae of the diamondback moth (fig. 25, *B*) and white butterfly. An aphid, a leaf miner, and flea beetles sometimes cause damage. Diseases consist of black rot, leaf spot, and knotty roots due to nematodes. They are usually not a factor during the cool, relatively dry season.

SPOON CABBAGE.—This is sometimes erroneously called white mustard. It is the nonheading oriental cabbagelike mustard that may have long upright spoon-shaped leafstalks. Some varieties have a spreading growth with short, broad leafstalks. Each package of seed is likely to show much variation among the plants. Seeds may be planted in the field at specified planting distances or seedlings may be transplanted from pots or seedbeds. They require the same management as head cabbage, including a complete fertilizer at planting with a side dressing of ammonium sulfate 4 to 6 weeks after planting. In Hawaii the varieties Shakushina and Pak Choy are used.

INSECTS AND DISEASES.—Except for mosaic and white rust the diseases and insects are the same as for head cabbage. Mosaic is controlled by weed eradication, rotation, and special control of aphids. White rust is best controlled by using furrow irrigation instead of sprinkling and by eliminating weeds. During rainy periods bordeaux mixture may be helpful for checking the white rust.

Since bordeaux mixture is a compound composed principally of copper sulfate, the precautions on page 98 should be followed.

Carrot

Carrots tolerating a temperature range of 60°–75°F. (fig. 24, *D*) are a fairly dependable crop in the Tropics. In Puerto Rico, they have been grown satisfactorily every month of the year at high and low elevations, but they perform best during the cool winter and spring seasons. Carrots tend to be "strong" and tough under high-temperature, dry conditions, and their coloring is weak under a combination of high temperature and heavy rainfall. The main limiting factor with planting carrots during the heavy rainfall season is that the seeds and delicate seedlings may be washed out of the soil. Windbreaks are essential in windy areas.

Carrots develop best in light, sandy, well-drained soil. In heavy soil the roots may be gnarled, poorly shaped, and difficult to prepare for cooking. In Puerto Rico, Danvers Half Long has been superior in yield to Imperator, Chantenay, and Morse Bunching in the heavier soils. Germination may be low during hot, dry weather. A mulchy covering of well-rotted manure or similar material (fig. 16, *H*) is a great help in keeping the soil moist during germination. Seeds should be distributed in a row 4 inches wide so that the carrots will later stand 2 to 3 abreast in the row. When about the size of the little finger, the plants are thinned so as to stand about 2 inches apart. Thinnings can be used in salads. Roots are right for table use when about 1 inch in diameter at the crown. If they are to be sold on the market, it may be desirable to harvest them larger; the smaller roots tend to shrivel rapidly.

The soil should be kept as uniformly moist as possible. A period of wet weather following a dry spell may cause splitting of the roots (fig. 23, *F*), which may be followed by rotting.

Insects and diseases.—Leaf blight may cause severe to light defoliation during extended rainy periods, but foliage usually reappears and good crops may be harvested if the rains cease and bordeaux spray is applied. Overhead irrigation may aggravate the disease. Other diseases include bacterial rot and soft rot of the roots. Flea beetles and leafhoppers may be present, but are usually minor pests. Cutworms destroy small seedlings.

Cassava or Manihot (Tapioca)

This shrubby perennial is grown widely in the Tropics for the large fleshy, tuberous, starchy roots which are frequently used in soups and stews and from which a coarse meal, bread, and the tapioca of commerce are made. There are bitter and sweet types. The bitter type, grown mainly as a vegetable, contains a higher percentage of poisonous hydrocyanic acid in the juice of the roots than the sweet type. The poison is dissipated, however, when the tubers are pared, grated and washed, boiled or roasted, or made into meal and bread. The starch, which is obtained from the roots by grating, is washed and pressed through fine-screen meshes and heated on a hot plate to form the granulated commercial tapioca.

Cassava is relatively drought-resistant and best suited to rich friable soils of the lower elevations. It is a heavy feeder and should not be planted on the same ground more than two or three times in succession unless a good fertilization program is maintained. Propagation is by 10- to 12-inch stem cuttings planted 3 feet apart in rows 4 feet apart during periods when rains are most likely to fall. Tubers can be harvested within 9 to 12 months from planting, depending upon climatic conditions and variety. Five to 8 tons or more of tubers may be obtained from an acre, depending chiefly upon soil fertility.

Insects and diseases.—A tip maggot, a beetle borer of the stem, and a sphinx caterpillar attacking the leaves are mostly minor pests in the West Indies. Discoloration and dying-back of the tips caused by *Gloeosporium manihot* sometimes cause trouble in Puerto Rico.

Cauliflower

Only fair crops of Indian Early Patna cauliflower have been grown during the cool season at low elevations. At Maricao (2,600 feet) from

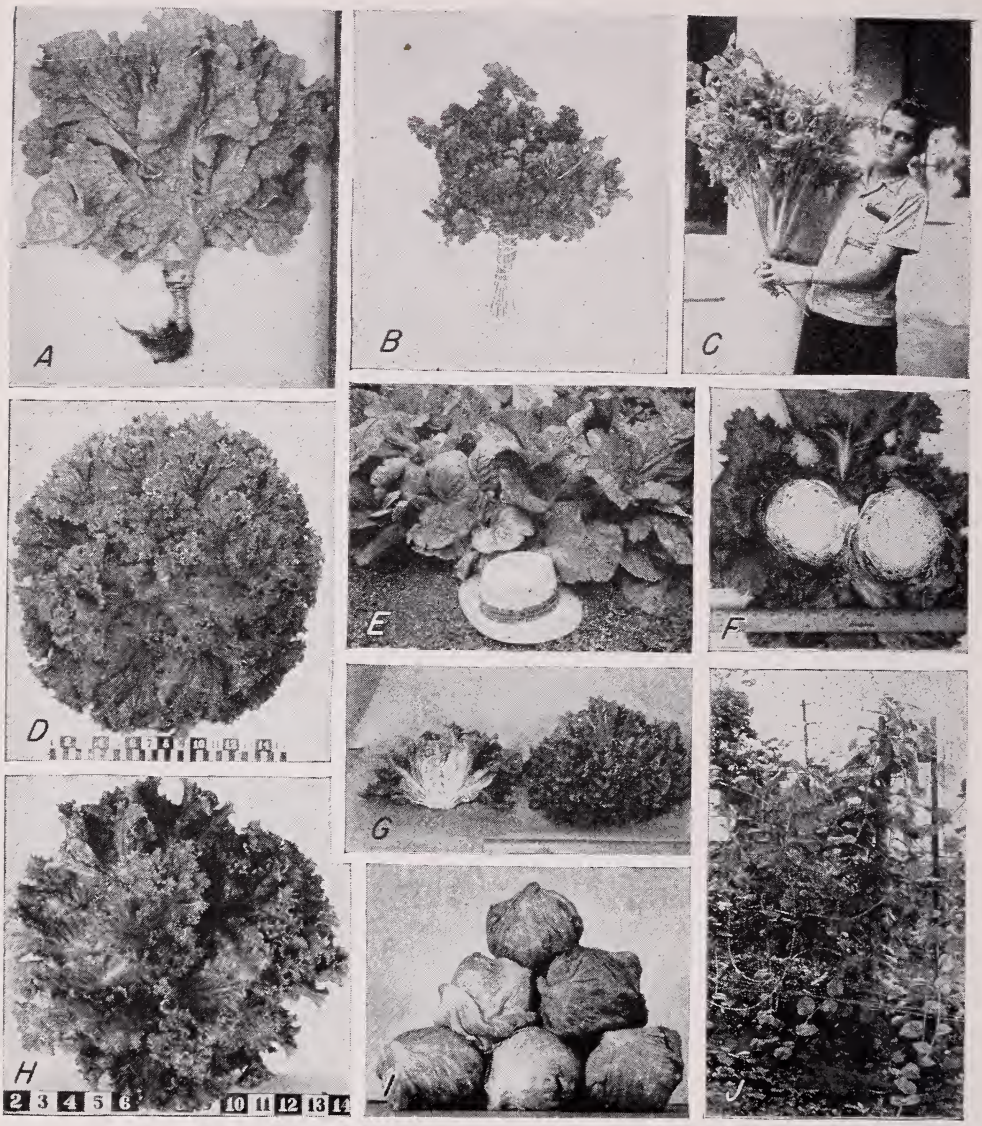


FIGURE 27.—*A*, Black Seeded Simpson leaf lettuce, a widely-grown winter variety in the Tropics.

B, Extra Curled Dwarf parsley grows particularly well at Toro Negro.

C, Golden Self-Blanching celery from Maricao.

D, Slobolt leaf lettuce grown during winter at Mayagüez.

E, Florida Broad Leaf mustard at Maricao.

F, Great Lakes head lettuce grown near Maricao.

G, Endive (Broad Leaved Batavian) grows well at all elevations, but quality was best at Toro Negro at 3,300 feet.

H, Slobolt leaf lettuce does not readily form flower stalks in summer at Mayagüez (compare bunch size in *A*, *D*, and *H*).

I, Heads of Imperial 44 lettuce from Maricao.

J, Ceylon spinach, also called "Malabar Nightshade" (*Basella rubra* Linn.), near Vega Baja.

50 to 75 percent of the plants formed small to medium heads (fig. 26, *F*). Cauliflower is exacting in climatic requirements and should be grown only during the cool months at high altitudes, where the mean temperature is between 55° and 65°F. Cauliflower is not a particularly good home garden crop in the Tropics. Handling of the seedlings and cultural requirements are about the same as for cabbage. On very acid soils lime should be added to bring the pH to 5.5 to 6.5. Blanching, if desirable, is done by tying the outer leaves over the flower cluster for a few days to protect it from the bright sun.

INSECTS AND DISEASES.—Same as for cabbage.

Celery

Celery grows best under the cool conditions of high altitude where the mean temperature is between 60° and 70°F. (fig. 27, *C*). Celery is best suited to a climate of warm days, cool nights, and abundant sunshine. The percentage of good bunches grown during cool months at sea level in Puerto Rico (Mayagüez) was less than 50. The somewhat tougher stalks of the small bunches at sea level, however, may be utilized to flavor soups and salads. Celery will occupy the soil for the relatively long period of about 5 months before reaching full maturity. Plants may be harvested, however, at any time after they are half grown.

Unless celery receives special attention in fertilization, spraying, and irrigation it is almost bound to fail. It does not perform well on light sandy soil or very heavy clay. Heavy additions of organic matter in the form of manure or compost are necessary in most soils and will improve the chances for success in light sandy soil or very heavy clay. A trench about 12 inches deep should be dug and partly filled with the manure or compost and then covered to the top with soil.

Seed should be sown in specially prepared seedbeds or flats of rich soil. When the seedlings are a few inches high they are transplanted to pots or another seedbed. Seeds germinate best if pretreated by being placed between moistened cloths for 1 or 2 days before planting. A thin mulch over the seed keeps the soil moist during germination. Partial shade for the delicate seedlings is advisable.

A complete fertilizer high in nitrogen, such as 10-10-5, should be applied in shallow trenches on either side of the plants at transplanting. This application is repeated in about 4 weeks, followed again by another of ammonium sulfate as a side dressing within 2 to 3 weeks.

Celery quickly suffers from lack of water during droughts. Irrigation at frequent intervals, preferably by furrows, is necessary to keep the stalks tender, well-flavored, and growing rapidly. The plants may be spaced about 6 to 8 inches apart in the row. Slightly closer spacing will aid in blanching, but also will reduce plant size.

The Golden Self Blanching variety has yellowish leafstalks and does not require blanching, although this practice helps reduce the "strong" flavor and increase quality if the crop has been grown under high temperature and dry conditions. Green varieties are blanched by wrapping and tying heavy paper around the bunch for some 10 days before harvest. Blanching should be done during a cool dry period, as warm moist weather may cause rotting of the wrapped plants. Although green varieties, such as Utah, require special blanching procedure,

some gardeners prefer to eat the green stalks or chop them into small pieces for soups. The green stalks are more nutritious than the yellow ones.

INSECTS AND DISEASES.—Insects that may become serious on celery are pineapple mealybug and woolly bear caterpillars. Nematodes also may be troublesome. Leaf spot is more a problem during heavy rainfall periods or with overhead irrigation. A soft rot which begins at the crown of the celery may destroy scattered plants.

Chard

Swiss chard, or leaf beet, is easy to grow and succeeds in the Tropics because of its wide tolerance to heat (65° to 80°F. (fig. 28, *C*)). It grows well throughout the year in Puerto Rico, but is particularly tender during the winter and at high elevations. Chard lacks the fleshy root of the beet. The entire tops may be eaten for greens or the crisp leafstalks and midribs may be separated and cooked like asparagus or celery.

The seedlings should be thinned to 6 to 12 inches apart in the row. First leaves should be ready to eat within about 60 days. The outer leaves of a bunch should be cut regularly as they reach tender maturity; new leaves will continue to develop and furnish high-quality greens for several months.

Chard requires a complete fertilizer at planting, manure if available, and side dressings of ammonium sulfate at about 3-week intervals thereafter. Frequent irrigation should be provided during dry periods to keep the plants tender and growing rapidly.

INSECTS AND DISEASES.—Same as for beet.

Chayote

The chayote is a cucumberlike vine that bears pear-shaped yellowish-green, wrinkled, sometimes spiny fruits (fig. 28, *A*). It grows satisfactorily at all altitudes in Puerto Rico, but best above 1,000 feet. The chayote prefers a moderately rainy climate; it grows poorly in dry regions. Two or three plants trained onto the fence should be adequate for an average family.

The chayote is propagated by planting the matured fruits horizontally, with the large end slightly downward and thinly covered with soil. Shoot cuttings taken from the base of the plant can be rooted in special shaded beds and transplanted as soon as a number of roots have formed. The seedbed should contain a mixture of manure and commercial fertilizer. Plants are spaced 4 to 6 feet apart along the fence or trellis. Side dressings of a complete fertilizer at monthly intervals keep the vines vigorous and bearing. Fruits are harvested when of good size (½ to 1 pound each) and are cooked like squash. Harvest begins from 3 to 5 months after planting and extends over several months.

INSECTS AND DISEASES.—Insects—of only minor importance—include aphis, pickleworm, and other pests of cucumber. Diseases include a leaf spot, leaf blight, and powdery mildew, none particularly serious.

Chinese Cabbage

Chinese cabbage is one of the easiest and most productive vegetables grown in the Tropics (fig. 26, *A*); returns are among the best for the

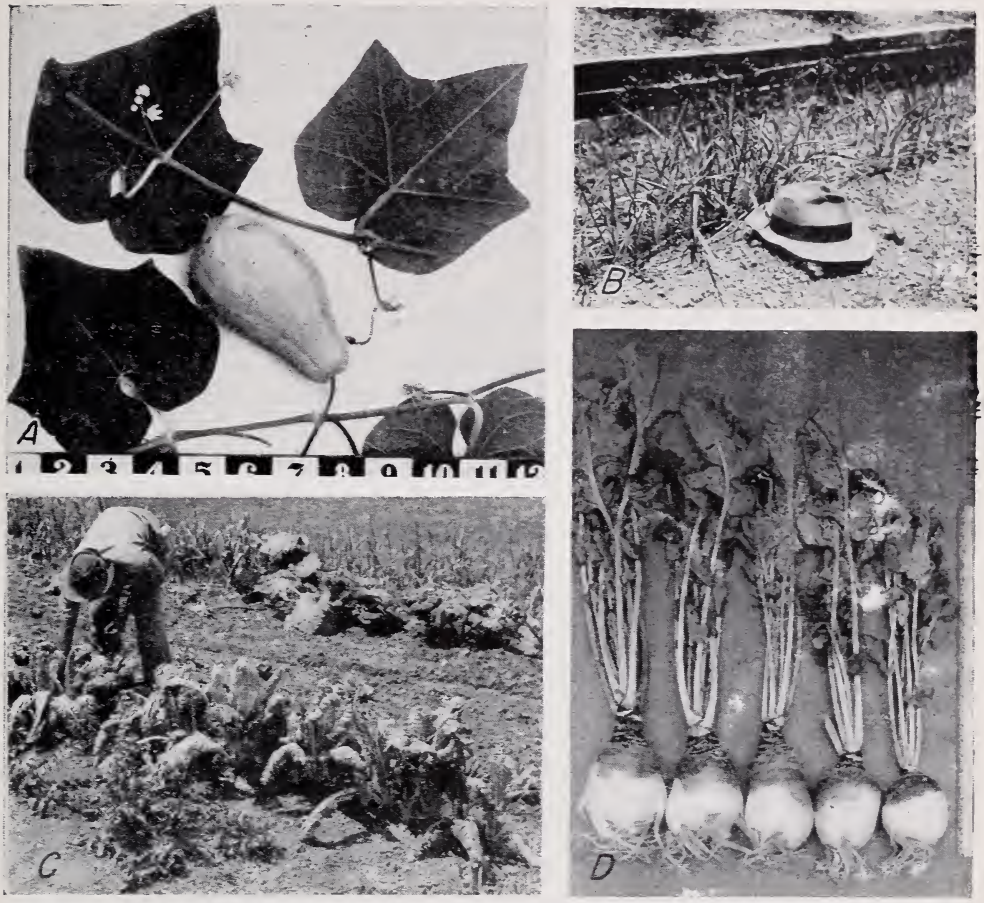


FIGURE 28.—*A*, The chayote will grow and produce well on the garden fence.
B, Salsify (vegetable-oyster) performed satisfactorily at 3,300 feet.
C, Chard succeeds at all altitudes in Puerto Rico. Note parsnip in foreground and rhubarb, leek, and bunching onions in background, located at Toro Negro (3,300 feet) in August.
D, Rutabaga resembles turnip; it grew well to 2,600 and 3,300 feet altitude in Puerto Rico.

labor and garden space involved. Where greens, celery, and head cabbage are scarce, this vegetable is popular, particularly in chopped salads, among people accustomed to eating leafy vegetables. Chinese cabbage can be grown practically all year at all elevations in Puerto Rico but forms the largest and best quality heads during the cool season. Surprisingly large heads, however, were marketed at San Juan during the warm August of 1946 from a nearby large commercial farm. During the warm season, when Chinese cabbage tends to form loose heads, the young leaves may be cooked for greens. The Chi-Hi-Li variety with long tapering heads was more in demand on the Station market than the Wong Bok or Pe-Tsai. Chiefoo, also recommended in Hawaii, forms short, thick heads like Wong Bok and Pe-Tsai.

Chinese cabbage can be transplanted like head cabbage, although excellent results have been obtained by planting seed directly in the field row and later thinning to one good plant at 10- to 12-inch intervals. A satisfactory crop can be obtained somewhat sooner by direct seeding.

Chinese cabbage should be kept growing rapidly by a side dressing of nitrogen or complete fertilizer when heads begin to form and by regular irrigation if necessary. The heads are harvested when solid and from 6 to 8 inches across (fig. 26, *A*).

INSECTS AND DISEASES.—Pests and diseases are the same as for cabbage. Rotting during warm rainy weather may be reduced or prevented by harvesting the plants while young and tender. This is desirable also from a quality standpoint, because leaves may quickly become "strong" flavored under these conditions.

Collard

This nonheading cabbagelike vegetable is the most heat-resistant member of the cabbage group. It thrives particularly well during the cool season in Puerto Rico above 1,000 feet. Quality was best at Toro Negro (3,300 feet), where it grew well throughout the year. The outer leaves of collards are removed when tender and of fair size and cooked like greens. The plants may grow to a height of 4 to 6 feet before seeding.

The seed can be planted directly in the row and the seedlings thinned to 6 to 8 inches apart. As the plants become larger they should be thinned again by being cut off below the ground surface. Leaves of the thinned plants can be used on the table.

INSECTS AND DISEASES.—Same as for cabbage.

Sweet Corn

Sweet corn varieties of continental origin have been consistent failures in Puerto Rico, owing chiefly to susceptibility to corn mosaic and *Helminthosporium* leaf spot. A similar condition has been reported in Cuba (*8*), Hawaii (*13*), and Venezuela (*25*). The USDA-34 variety (fig. 14, *A*), developed by the Federal Experiment Station in Puerto Rico (*35, 1935, p. 13*), is a widely adapted sweet corn variety for the Tropics. Two varieties reported from Cuba—the Gondeva and Pajimaca—have shown somewhat more vigor of stalk and higher sugar content of the kernels than the USDA-34 under Cuban conditions (*8*). A variety developed by Langham (*25*) is successful at 3,000-feet altitude in Venezuela.[11]

Corn may need too much room for small gardens, but where enough land is available excellent roasting ears can be had throughout the year by succession plantings. The USDA-34 variety performs best at lower elevations. Fair to good crops were obtained at Maricao (2,600 feet) during spring and early summer; only fair to poor crops were obtained in early spring at Toro Negro (3,300 feet). A better sweet corn variety is needed for the higher elevations in the Tropics.

Complete fertilizer and manure where available should be mixed with the soil before planting. During the rainy season the seed should be planted on ridges 6 to 8 inches high and spaced 2 to 3 feet apart. Two or three kernels are dropped at intervals of 10 to 15 inches in the row. The plants are then thinned to one good stalk per hill. One or two side dressings of ammonium sulfate or a complete fertilizer are advisable at about 4-week intervals, beginning when the corn is knee high. Irri-

[11] It is doubtful if seed of improved Cuban and Venezuelan sweet corn is readily available to home gardeners throughout the Tropics.

gation is highly essential during dry periods to obtain a good yield of large-size high-quality ears.

The USDA–34 variety should produce from one to two good ears per plant. When ready for harvest the ears should be of good size and firm and should show dry brown silks at the tips. The kernels should be at the "milk" or "soft dough" stage, which can be determined by pulling back the shuck at the tip of the ear and breaking one or two kernels with the thumbnail. Ears should be checked frequently because the ideal stage for harvest lasts for only a day or two before the kernels become tough.

Insects and diseases.—The fall armyworm may attack the plants from the time the seed germinates until the ears mature. Their damage is usually moderate but can be severe at the beginning of the dry season (fig. 29, *D*). The silk fly (fig. 23, *B*) and corn earworm, or tomato fruitworm, damage the tips of the ears (*4, p. 1*). USDA-34 is slightly susceptible to *Helminthosporium* leaf spot during warm wet weather. Ears selected for seed should be large and from plants free from disease.

Cowpea

The cowpea, like other legumes, is high in food value. It grows satisfactorily at all elevations in Puerto Rico, but yields less during the heavy-rainfall season. Blackeye, Brown Crowder, and Cream Lady performed satisfactorily under Mayagüez conditions. Yields of Yardlong (pole type) were only fair. The pods when young and tender can be used like "snap" beans, or the seed can be allowed to develop to the green tender stage and cooked like lima beans. The beans also can be left to mature, then harvested and cooked like dried beans. The cowpea will grow on a wide variety of soils provided drainage is good. Culture is similar to that for soybeans. In the southern United States it is frequently interplanted with corn.

Insects and diseases.—Two leaf spots and powdery mildew usually are not serious. Bean leaf beetles and leafhoppers may be serious during the summer. Aphis is more likely to attack during the dry season.

Cucumber

Cucumbers are widely grown in Puerto Rico, both for export (*44*) and local market (fig. 30, *B*). Only a few hills are needed for the home garden. However, the vines take up more room than most other vegetables, bear over a comparatively short period, and produce a fruit of low food value. To save space in the small home garden the vines may be trained over a fence or trellis.

The Puerto Rico 39 variety developed by the Agricultural Experiment Station of the University of Puerto Rico at Río Piedras, is widely grown because of its resistance to mildew. Its quality is not so good as that of most continental varieties, however. Such varieties as Black Diamond, Straight Eight, and Henderson may be grown successfully in the dry sandy regions of Isabela and Ponce at sea level, provided weekly to 10-day applications of bordeaux mixture are made during rainy periods, and regular irrigation is provided when needed. Yields of 7,000 pounds per acre were obtained for the Henderson variety at the United States Army Air Base near Isabela (fig. 30, *B*). One or two shovelfuls of manure or well-rotted filter-press cake from sugar mills should be placed in each hill.

FIGURE 29.—Several important pests of vegetables in the Tropics: *A*, The tobacco hornworm (*Protoparce sexta* (Johan.)) is an extensive feeder on leaves of tomato, eggplant, and pepper; *B*, a leaf bettle, *Andrector ruficornis* (Oliv.), often riddles the leaves of beans and other legumes; *C*, rasping of the leaves of onions by the onion thrips (*Thrips tabaci* (Lind.)) limits production in many places; *D*, tops of sweet corn are often shredded like this by the fall armyworm (*Laphygma frugiperda* (A. & S.)), which also attacks many other garden crops and grasses. (*A*, *B*, and *C* ½ natural size.)

In the use of bordeaux mixture, which is a compound composed principally of copper sulfate, the cautions on page 98 should be observed.

Cucumbers can be harvested at any size and at any stage of maturity, but they should be gathered at 2- to 3-day intervals. Production will be

FIGURE 30.—*A*, Tom Watson watermelon grown at Borinquen Army Air Base, Aguadilla. *B*, Puerto Rico No. 39 mildew-resistant cucumber at Puerto Rico Agricultural Experiment Substation, Isabela. Note planting method for irrigation. *C*, Cocozelle squash at Maricao. *D*, Native calabazas of different sizes, shapes, and colors obtained on the Río Piedras market; quality of most of these strains is fair to good, but yield is relatively low.

reduced if the fruits are allowed to attain full size and maturity.

INSECTS AND DISEASES.—Same as for pumpkin and squash. A "leak" disease of the fruit may be serious during humid weather in the field and in shipment.

Eggplant

The eggplant is a popular warm-season (70° to 80°F.) crop in the Tropics. It grows well throughout the year at low elevations in Puerto Rico, and gives fair to good yields at altitudes up to about 2,500 feet during the warm season. Eggplant was a complete failure above 3,000 feet. Three to five good plants should be adequate for the average-size family. The young plants produce the most and best fruits, but the older plants may continue to produce fair to good fruits for a year or more.

The pink long-fruited Rosita variety, developed by the Agricultural Experiment Station of the University of Puerto Rico, is resistant to the frequently destructive bacterial wilt and, thus, is one of the most popular varieties in Puerto Rico (fig. 22, *D*). Black Beauty gave high yields under Mayagüez conditions, but this variety should not be planted where bacterial wilt is a problem. Seeds are soaked overnight to improve germination before planting in a seedbed. The seedlings are grown to the 3- or 4-leaf size, transplanted to another seedbed, and eventually set in the field at a height of 5 to 7 inches. It is important to keep young plants growing vigorously by regular irrigation when necessary and spraying with DDT to keep the foliage free from flea beetles and lacebugs. Any early set-back to the young plants will significantly reduce yields.

Side dressings of a complete fertilizer at monthly intervals when the plants begin to produce (fig. 20, *A*) should help maintain production over many months. Irrigation by furrow is essential during dry periods.

Fruits should be harvested regularly when they are of good size and the skin shows a slick luster. Fruits allowed to become mature on the plants will reduce subsequent yields. Where bacterial wilt is common in Puerto Rico, eggplant is sometimes grafted onto the native *Solanum torvum* Sw. because of its immunity to the disease.[12] Apparently this understock does not impart any undesirable qualities to the eggplant fruit.

Insects and diseases.—Lacebugs and flea beetles are probably the most important insects attacking eggplant in the West Indies. An aphid, hemispherical scale, a leaf roller, and a large number of minor pests may occasionally cause damage, probably because of the wide distribution of closely related wild plants.

Anthracnose, fruit rot, a leaf spot, a stem canker, and a bacterial wilt may tend to reduce yields, particularly when eggplant or closely related vegetables, such as tomato, potato, and okra, are planted successively on the same ground.

Endive

Endive is used on the table like lettuce, or it may be cooked like spinach (fig. 27, *G*). Quality and growth are best during winter and spring at high altitudes. Endive will withstand light freezes (*51, p. 262*). It can be grown throughout the year at all altitudes, but the leaves tend to be "strong" and tough during warm weather; rotting of the centers also may be a factor during the rainy season. Growth is

[12] Caution should be taken not to graft eggplant on a poisonous *Solanum* sp., or *Datura stramonium L.* (jimsonweed), which is known to impart poison in harmful quantities to the fruit.

best where a plentiful supply of manure and commercial fertilizer is used in preparation of the bed. The seed may be sown in rows about 18 to 24 inches apart and the seedlings later thinned to 8 to 12 inches apart in the row. A side dressing of ammonium sulfate 4 to 6 weeks after the seedlings appear will help maintain good quality and tenderness of the foliage. When the bunches have reached good size, the leaves may be tied together for 10 to 14 days to blanch the center leaves. The broad-leaved Batavian variety forms a large rosette of leaves with the center ones naturally self-blanching. If rain falls frequently during the blanching period, the bunches should be inspected daily, so that those that begin to show rot at the centers may be harvested immediately.

INSECTS AND DISEASES.—Endive is relatively free from insect pests except for an occasional infestation by aphids.

Kale

Kale is grown in the same way as the collard. It is a much smaller plant, however, and the quality of its leaves is not comparable with that of the collard's leaves, although this is a matter of opinion. The outer leaves are removed when of fair size and still tender and cooked as greens. This vegetable performs best above 1,000 feet in Puerto Rico; fair crops have been obtained during the winter at sea level. A few feet of row devoted to this vegetable should be adequate in a home garden.

INSECTS AND DISEASES.—Same as for cabbage.

Kohlrabi

Propagation and culture of kohlrabi is similar to that for cabbage. Seed can be sown directly in rows, however, and the plants thinned to 4 to 6 inches apart. Best crops can be obtained at the higher altitudes during most of the year and at the low altitudes during the cool season. The above-ground enlargement of the stem (fig. 26, *B*) is peeled and cooked like a turnip; in fact, it is frequently sold on the tropical markets for a turnip. Early White Vienna variety performed well in the test gardens. The bulblike stem should be harvested when about 2 inches in diameter; it becomes stringy and of poor quality when allowed to grow large.

INSECTS AND DISEASES.—The same as for cabbage.

Lettuce

HEAD LETTUCE.—Imperial 44 and Great Lakes head lettuce varieties produced moderately firm heads weighing from 1½ to 3½ pounds at 2,600 feet altitude, Maricao, P. R. (fig. 27). At sea level Imperial 44 produced fair heads weighing from ¾ to 1½ pounds (cover), but this could be done only from December to March, inclusive. Formation of good heads was less than 75 percent, particularly at low altitudes. Nonheading plants can be used for their crisp green leaves. The several continental head lettuce varieties tested at sea level in Puerto Rico produced flower stalks quickly during summer.

The Mignonette variety forms small high-quality heads during the cool season at sea level and is popular among people accustomed to eating head lettuce. The purplish-green color of the leaves makes this

variety unpopular with the local trade. Mignonette is more heat-resistant than most head-type varieties. It can be grown as a leaf lettuce during the summer, but should be harvested when young because of the possible development of bitterness. Tipburn of Mignonette during the summer can be prevented to some extent by regular furrow irrigation in dry periods.

The cos or romaine types of head lettuce may be grown during the winter season at high altitudes. Heads are cylindrical, upright, and somewhat loose. Flavor of this lettuce when properly grown is excellent.

LEAF LETTUCE.—Leaf lettuce is popular in the Tropics. Light yellow beds of lettuce, principally the Black Seeded Simpson variety, are a common sight in and near the large cities during the cool season. Under warm temperature conditions in summer at Mayagüez, Black Seeded Simpson is not well adapted because it sends up flower stalks, thus reducing the number and size of the leaves. The United States Department of Agriculture at Beltsville, Md., has developed a heat-resistant leaf lettuce known as Slobolt, which resembles Black Seeded Simpson in appearance but is better adapted to year-round tropical conditions (*6*). Slobolt, as the name indicates, is slow to send up flower stalks under high-temperature conditions. Very large bunches can be grown in the cool season and medium-size ones can be grown in summer (fig. 27). This variety is particularly recommended where the mean temperature is between 75° and 80°F.

Leaf lettuce can be planted directly in the garden and later thinned, using some of the thinnings on the table and transplanting others to new rows on either side and close to the main row. Thus, these side rows of seedlings are ready to harvest when the plants in the main row are about gone. For this type of management the original rows should be spaced 18 to 24 inches apart.

A method frequently used in small market gardens in Puerto Rico is to sow the seed over well-manured raised beds (figs. 5 and 18). Seedlings are transplanted at the 3- to 4-leaf stage to neighboring beds at distances of 6 to 8 inches both ways.

A liberal supply of manure and a complete fertilizer relatively high in nitrogen should be used at planting. Leaf lettuce must be kept growing rapidly by frequent furrow irrigations during dry periods and by a side dressing of ammonium sulfate 2 to 3 weeks after the seedlings are up and well established. During the summer the use of cheesecloth, burlap, palm leaf, or lath shade to reduce the heat of the sun is helpful in growing crisp, sweet leaves.

Leaf lettuce is a good crop to interplant with slow-maturing large crops, such as corn, tomato, and eggplant. In fact, lettuce grows well and is often of higher quality when cultivated under the medium-to-thin shade of these plants. Leaf lettuce can be harvested within 30 to 40 days after planting. Entire plants may be harvested, or only the lower leaves of a stalk may be removed when of good size, thus permitting the plant to continue to produce new leaves for a month or longer.

INSECTS AND DISEASES.—The main disease affecting the leaves of both leaf and head lettuce is *Cercospora* spot, which develops during wet weather or after frequent overhead irrigation. The Slobolt leaf lettuce variety is relatively resistant. Bottom rot or scald of the stalk may cause some losses. Mosaic may cause stunting and small light

and dark green spots on the leaves. Aside from minor damage by aphids and leaf tiers, lettuce is relatively free of insect injury.

Muskmelon

Best yields of muskmelon have been obtained during the winter in sandy loam soils in the relatively warm dry regions of Isabela and Ponce, P. R., at sea level. Fair to good crops also have been obtained in summer, but diseases were sometimes troublesome owing to high rainfall. The Smith Perfect variety performed satisfactorily in the Isabela region (*39*). A native mildew-resistant cantaloup is grown in winter, principally near Ponce; its quality is fair to good, but yield is low. Yields of this and several other varieties on heavy soil in winter at Mayagüez were poor despite fair to good vine growth. Muskmelons are widely grown in India (*62, p. 322*); Chitla of Lucknow and Sardi are popular varieties.

This dessert vegetable, like the watermelon, requires extra space in the garden, is not easy to grow, and is low in food and vitamin value. Culture and management are much the same as for the watermelon. Weekly to 10-day sprays with bordeaux mixture for mildew are usually necessary, particularly during rainy periods. A well-drained irrigated sandy loam soil with a pH of 6.0 to 6.7 is desirable. When the melon nears maturity the color changes from dark green or grayish green to yellowish green. For home garden use the melons can be left until the fruit slips from the stem.

Insects and Diseases—Same as for pumpkin and squash.

Mustard

Green mustards, which are served in salads or cooked as greens, grow well in the Tropics (fig. 27,*E*). Growth and quality are best during the cool season at high altitudes. Fair crops were grown at sea level (Mayagüez) in summer, but for acceptable quality it was necessary to harvest the leaves when young. Seeds are planted in rows 12 to 15 inches apart and the plants later thinned to 6 inches apart. A few feet of row should supply the needs of one family. Leaves are ready to harvest in about a month. The outer leaves of the bunches should be harvested when full grown but still tender. If harvested later, they will become tough and "strong." The plants tend to go to seed during the spring and summer and should be harvested completely when the seedstalks begin to appear.

Insects and Diseases.—Appears to be free of disease. Insects same as for cabbage.

Okra

Okra is well adapted throughout the Tropics. It yields best at sea level, particularly during the warm months in regions where rainfall is not likely to be excessive. At Maricao (2,600 feet) a good crop was obtained in June, but later plantings could not be established because of heavy rains. A few plants are sufficient in the average home garden, as when well tended they will bear for several months. The White Velvet variety has outyielded all other varieties in several trials at Mayagüez. Germination can be improved by soaking the seed for a day before planting; unswollen seed should be discarded. The seeds are planted in hills 18 to 24 inches apart in rows 30 to 40 inches apart. Plants are later

thinned to 2 to 3 good plants per hill. The plants should be kept growing rapidly by regular irrigation when necessary and by side dressings of a complete fertilizer at 4- to 6-week intervals. The pods must be harvested at intervals of every 2 or 3 days when the tips are tender and break with a "snap." If pods are left to mature on the plants they are too tough for consumption; such a practice also reduces yields.

Okra may be boiled and used in soups. Or it may be combined with tomatoes and other vegetables to give a dish that tends to be "slick" but still is liked by many people. Another method, preferred by some, is to slice the pods into ¼- to ½-inch pieces, roll in corn meal or flour, and fry in fat.

Insects and Diseases.—A fungus causes spotting, yellowing, and dropping of the older leaves, particularly during heavy rainfall periods. Another fungus causes blighting of the flowers and rotting of the young fruits. An aphid (fig. 31, *A*), leaf beetles, and the West Indian peach scale may be minor pests.

Figure 31.—Cotton aphid, or melon aphid (*Aphis gossypii* Glov.) on okra:
A, Adults and young on cluster of flower buds; the irregular white spots are the young and their molted skins.
B, Wingless adults and young on lower surface of leaf. (*A* and *B*, about natural size.) A serious pest of cucumber, melons, and other vegetables. Aphids can do great damage, especially during dry weather, if not controlled as soon as noted and before leaves curl.

Onion, Garlic, and Leek

Bulb Onion.—The Bermudas and Louisiana Red Creole (*40*) are the best bulb onion varieties for Puerto Rican conditions. The plants form the largest and best bulbs if the seed is sown in seedbeds in late fall and transplanted to the garden when the stem diameter is about the size of a pencil. The bulbs then enlarge and mature as the days lengthen in March, April, and May (fig. 7). Most varieties of bulb onion remain vegetative and do not form bulbs if they mature during the short-day (11- to 12-hour) winter season. In fact, many varieties that bulb at

high latitudes (as in northern United States or Europe) will not bulb at any season in the Tropics.

Bulbs may be harvested before they mature or they may be allowed to mature fully. The tops break over near the neck as maturity approaches, at which time it is good practice to break over all the tops so that the crop will mature uniformly. Bulbs are harvested and allowed to dry for a few days before they are stored in a dry well-aerated place. Bermuda onions will keep for only a few weeks at best; Creole onions can be stored for months. Bulb onions will keep longer under refrigeration.

Garlic.—Garlic is widely used in the Tropics as flavoring in soups, meats, and stews. The plants produce several small bulbs or cloves instead of one bulb like the onion. The cloves are used like onion sets for propagation, giving better results than seed. Cultural and climatic requirements are similar to those for the bulb onion. The crop performs best if planted at the beginning of the cool season at low to medium altitudes. Garlic is harvested about 10 weeks after planting and after the tops have died. The cloves are cured for about 2 weeks in a warm dry place.

Green Bunching Onion.—The bunching onions are popular for home gardens. They are excellent when eaten raw, either alone in salads or sandwiches, and also when added to soups. A native variety and the New Long White Bunching variety derived from continental sources grow well throughout the year at all elevations in Puerto Rico (fig. 22, *A*). In fact, the bunching onion was one of the few vegetables that consistently survived heavy rainfall in the trial gardens.

Sets or side shoots of native varieties can be obtained at almost any time of the year from local growers or through the tropical experiment stations. They are set directly in the field. Seed of the New Long White Bunching can be obtained from continental seed houses. The seeds are first planted in close rows in seedbeds. When the seedlings are 6 to 8 inches high, they are transplanted in the garden to a depth of 1½ inches and at distances of 3 to 4 inches in rows 12 to 18 inches apart. Rows can be planted 6 inches apart to save space, but weeding and cultivation then become tedious. In transplanting, the tops are clipped back to 3 inches and all but about ½ inch of the roots are removed. Once the crop is established from seed it may be propagated by divisions.

Leek.—Leek resembles bunching onion, but its leaves are flat, its tops are thicker, and only a single cylindrical bulb instead of many is formed. Culture is about the same as for the bunching onion except the soil is gradually mounded around the plants in the later stages of growth to blanch the stems. Leek may be used for flavoring or boiled and served in white sauce.

Insects and Diseases.—Green bunching onions have few insects and diseases; thrips may cause some, but usually not serious, damage. Thrips are often serious on bulb onions (fig. 29, *C*); the varieties mentioned are somewhat more resistant than others. Bulb onions may be susceptible to soft rot as they reach maturity, particularly if the weather is humid or wet just before harvest. If the weather turns wet, it is wise to harvest all matured onions immediately and cure them in a dry well-aired place, destroying the diseased bulbs. Black, powdery smut pustules—also a spot and anthracnose (on white varieties)—may appear on the

leaves. The Louisiana Red Creole variety seems more resistant to leaf diseases than other bulbing onion varieties.

Parsley

Parsley grows best throughout the season at the higher elevations (fig. 27, *B*), but fair crops can be grown in the lowlands. The leaves are harvested from the outside of the bunches and used for flavoring, garnishing, and to some extent in salads. Parsley is a short-lived perennial; one crop may be grown in the garden for a year or more. Temperate climate varieties, such as Extra Curled Dwarf or Moss Curled, do not go to seed under Puerto Rican conditions as do the smooth-leaved varieties, which are more popular locally. The small seeds are sown about ¼ inch deep and covered with a mulch until the plants begin to appear. Seeds will germinate better if soaked for 12 to 24 hours before planting. A complete fertilizer at planting and subsequent side dressings of a nitrogen fertilizer at monthly intervals will help keep the leaves vigorous and tender. Only a few plants in the garden will supply all home needs. There is some market demand for parsley during the holiday season and Holy Week in Latin America, but the market can be quickly flooded.

Insects and Diseases.—Insects attacking parsley are the same as those for celery. A leaf blight may almost defoliate the plants during the hot rainy season, but the plants usually recover completely with the advent of drier weather.

Parsnip

Good crops of parsnips were grown at Toro Negro (66.8°F.), particularly when planted in late winter (figs. 24, *E* and 28, *C*). A fair crop was obtained at Maricao at this period when irrigation was provided. A long season—4 to 5 months—is required for maturity. The soil should be prepared to a depth of 10 to 12 inches to facilitate the deep-rooting habit of this vegetable. Culture is about the same as for beets. Parsnip seed is sown in rows 15 to 18 inches apart for hand cultivation. As germination is slow, it is recommended that radish seed be mixed with parsnip seed for home gardens. The radishes will serve as an extra crop and also mark the row until the parsnip seedlings appear. Parsnip seed is extremely short-lived under warm humid conditions, so that special care is required to keep it viable (p. 31). When the plants are 5 to 6 weeks old they should be thinned to 2 to 4 inches apart in the row. Special weeding attention must be given to the delicate seedlings; otherwise they will be smothered by weed growth.

Quality of the Hollow Crown variety of parsnip grown at Toro Negro was good. Cooked by the standard system of sugaring and buttering, these parsnips were as good as or better than those grown in the North.

Pea

Peas are a good home-garden crop in the highland Tropics, particularly for people accustomed to the flavor of fresh peas as compared with the canned product. The market demand for fresh peas, however, is not great in the Tropics because most of the people are in the habit of using canned peas, which are readily available, cheaper, and easier to prepare.

The common garden (English) pea does not grow successfully at low

elevations even in winter. The temperature range for good production is relatively low and narrow (55° to 65°F.). During winter and spring, fair to good crops of the Telephone variety were grown at Toro Negro (3,300 feet). Melting Sugar, the edible-pod (Chinese) variety performed better at both Maricao (2,600 feet) and Toro Negro, producing almost twice as much as Telephone. In fact, Melting Sugar gave fair to good summer crops at these higher elevations (fig. 4) and a fair winter crop at sea level.

Sometimes peas can be grown well on moderately fertile soil without the application of fertilizer. Complete fertilizers at planting and a later side dressing of superphosphate, however, appear desirable under most conditions. Fertilizer should be placed in furrows on either side of the row at a distance of 2½ inches and 1 inch deeper than the seed (fig. 16, *F*).

Double rows are planted 6 inches apart and later the seedlings are thinned from 2 to 6 inches apart in the row. Some support will be needed for the vines. A fence made of bamboo, chicken-wire, or small dead branches of trees stuck into the ground (fig. 4) may be satisfactory.

Pods of Melting Sugar peas are prepared and cooked like "snap" beans. They, too, may be used for shelled green peas if harvested when large enough but still tender. The time for this harvest is short, as peas of the edible-pod type quickly turn hard and starchy.

Insects and Diseases.—Leaf spot and powdery mildew were usually of minor importance, but at Maricao, where rainfall was heavy, both gave trouble. No major insect pests were noted under Puerto Rican conditions. Mites, thrips, and leaf tiers may be minor pests.

Pepper

Good crops can be obtained from sea level to 3,000 feet when peppers are planted in fall, winter, and spring; fair to good crops when they are planted in summer if rainfall is not excessive (fig. 22, *B* and 14, *E*). The mean temperature requirement is between 65° and 80°F.

Peppers have been grown for export near San Juan and Isabela (*44*). Mosaic is the main factor limiting pepper growing in Puerto Rico. The Agricultural Experiment Station of the University of Puerto Rico has developed several improved mosaic-resistant pepper strains that are thick-walled, sweet, and of good quality. These strains were developed by crossing native mosaic-resistant strains with a high-quality continental variety such as California Wonder. Unfortunately, the local trade prefers the thin-walled variety, but the thick-walled fruits of Puerto Rico Selection No. 21 are popular on the continental markets in winter and early spring, which is the shipping season from Puerto Rico. Selection No. 21 produced well at sea level and Toro Negro, but under heavy rainfall conditions at Maricao only a fair crop was obtained from plants established in the early spring. Propagation and management are similar to those for the tomato.

Peppers are harvested when of good size. Large sweet peppers are usually picked while still green in color. The fruits can be left on the plant after reaching maturity without deterioration. They are picked by cutting or breaking the brittle stems. For export market peppers are graded and sold in half-bushel and bushel containers or in 4- to 6-basket carriers.

INSECTS AND DISEASES.—Insects that may become pests are a mite, an aphid, and an armyworm. Diseases include mosaic, wilts, a leaf spot, anthracnose, soft rot, and spotting of the fruits.

Pigeonpea (Gandul)

Pigeonpea is a sure crop in the Tropics and should be included in every planting plan where the family is accustomed to eating this nutritious vegetable. The pigeonpea (*23*) is a perennial legume, but most varieties usually have to be replanted every second or third year. It can be used for a windbreak and should be kept 8 to 10 feet from the nearest vegetable to avoid heavy competition. The pigeonpea will grow on a wide variety of soils, attaining a height of 3½ to 4½ feet on poor dry soil and 11 to 12 feet on rich loamy soil in moist regions. It is one of the most drought-resistant vegetables because of its extensive fibrous root system which also serves as a soil-holding mat. The pigeonpea can be planted on the slope of bench terraces to hold the soil. It grows well at low to moderately high altitudes.

For a windbreak the seed is planted in rows 2 to 4 feet apart. For a tall woody windbreak, the blossoms should be removed for some time to promote thick vegetative growth. Seedlings should be thinned to about 2 feet apart at the end of the first year if the windbreak is to be maintained for 2 years or longer. If grown principally for food, the pigeonpea is planted 3 to 4 feet each way in hills with 2 to 3 seeds per hill. It is common practice to plant the pigeonpea in the same rows with corn.

In the West Indies there are two main varieties—a short-growing one known as "Totiempo," which is planted in March and bears for about 6 months, from November to April, and a tall variety, planted about the same time, and perhaps more productive, but fruiting for only 3 months, beginning in November. The seed may be gray, yellow, or red, according to the strain. Yields may reach 800 pounds per acre of seed when planted as a pure crop. The shelled half-ripe seed is stewed and eaten with rice or used in vegetable soups, curries, and the like.

INSECTS AND DISEASES.—Damping-off of seedlings may be a problem if the planting season turns cool and moist. Anthracnose, a rust, leaf spots, and a collar and stem canker are occasionally troublesome (*35, 1925, p. 38*).

Potato

The potato is a good home garden crop only when the climate is particularly well suited, equipment and materials for spraying are available, and the soil is fertile, well-drained, and preferably of the sandy loam type (fig. 24, *C*). The potato should not be included in the small garden where land is at a premium. It is not an easy crop to grow; amateurs frequently do not get their seed back.

The potato is native to the Andean slopes of South America. It produces tubers best with a mean temperature just above 60°F. (*51, p. 352*), but yields well with temperatures ranging between 60° and 75°. Little or no tuberization occurs above 80°. The Red Bliss Triumph, Green Mountain, and Katahdin varieties produced well—in the neighborhood of 200 to 250 bushels per acre—in a sandy loam soil at the substation of the Agricultural Experiment Station of the University of Puerto Rico (*36, 1945–46*) near Isabela, when planted in October to November and allowed to mature during the cool weather. Fair yields

of Red Bliss Triumph were obtained when planted in June. Day length is important in tuberization of some varieties (p. 10).

Seed stock should be certified and obtained from a reliable company. Seed potatoes used in the Tropics are frequently those shipped in for food or those saved from a locally grown crop—risky sources because of possible disease contamination.

A heavy application of complete fertilizer high in phosphorus and low in nitrogen, such as 3–12–12, 2–16–8, or 4–12–8, should be worked into the soil before planting or placed in furrows near the seed pieces at planting. Fertilizer must not touch the seed pieces or burning and rotting will result. Excessive use of manure or nitrogen gives excellent top growth but low yield of tubers.

Potatoes will mature within 90 to 100 days and should be dug on a dry day after most of the tops have died. They store best under refrigeration of 32° to 45°F. Potatoes stored at this temperature range will sweeten and darken excessively when fried. This can be prevented by leaving them at room temperature for a week after removal from storage before they are used. Where refrigeration is not available potatoes should be stored in a well-aerated cool place.

Insects and Diseases.—Insects attacking the potato under Puerto Rican conditions are leafhoppers, aphids, wireworms, cutworms, white grubs, and other minor pests of related wild plants. Diseases consist of early and late blights, scab, mosaic, and Fusarium wilt.

Pumpkin and Squash

Many native pumpkins and squashes (calabazas) are grown in Puerto Rico and the Tropics (fig. 30, *D*). These native strains are relatively resistant to insects and diseases. Their quality is fair to good, but their yields are low.

As squash and pumpkin take up a good deal of space, they should be planted only in large gardens. The Alagold variety, which originated in Africa, is relatively resistant to mosaic and other leaf diseases. The quality of its fruit is good, but yields are low, at least under Puerto Rican conditions. This variety, obtainable at continental seed houses, will trail over the ground for a year or longer, blooming heavily but setting lightly.

The Yellow Summer Crookneck variety produced satisfactorily under irrigation and in the sandy loam soil near Isabela. Good firm fruits were produced in 45 days. The Giant Yellow Summer Crookneck also produced well, being one of the showiest in the garden.

The Cocozelle squash grew and produced well at sea level and at 2,600 feet (fig. 30, *C*) during winter and early spring. It appeared to be more resistant to insects and diseases, but when grown successively on the same ground area these difficulties increased. Quality of Cocozelle is fair.

Pumpkin and squash are grown in hills spaced 6 to 8 feet apart for vine types and 4 feet each way for bush types. To conserve space, they can be planted in corn, grown near and on a fence, or at the edge of the garden, with the vines allowed to grow out over the adjacent grass. Best results can be obtained by digging a hole 2 feet wide and 1 foot deep for each hill, into which 2 to 3 shovelfuls of manure are placed with top soil covering the manure. Four to 6 seeds of pumpkin and 6 to 8 seeds of squash are planted 1 to 1½ inches deep in each hill. The

FIGURE 32.—Typical examples of the work of two leaf-rolling caterpillars on vegetables: *A*, The sweetpotato leaf roller (*Pilocrocis tripunctata* (F.)) and *B*, the melonworm (*Diaphania hyalinata* (L.)) (both ⅔ natural size). The latter sometimes also attacks the fruits of cucumber, melon, pumpkin, and squash. To control insects such as these, stomach poisons must be applied as soon as larvae are noted and before they have begun to roll the leaves.

seedlings are thinned to 3 per hill. A sandy loam soil rich in humus is best suited to pumpkin and squash, but they will tolerate heavier soils than other melons.

INSECTS AND DISEASES.—Downy mildew and mosaic are the principal foliage diseases. Insects include the melon aphid, squash bug, melonworm (fig. 32, *B*), pickleworm, and striped cucumber beetles.

Radish

Radishes are widely grown in the Tropics, being one of the easiest short-period vegetables to raise (fig. 24, *F*). Nearly all the varieties perform well. Earliest Scarlet Button is the most popular on the local markets. Radishes of this variety, although fair to good throughout the year, were of excellent quality when grown at the higher altitudes in winter. During the summer at sea level, when the temperature is high and particularly when a drought occurs 1 or 2 weeks before maturity, all radishes are likely to be tough, pithy, and very "hot." Also, the roots may elongate rather than enlarge normally. This can be prevented to some extent by enriching the soil with manure and commercial fertilizers and applying irrigation water regularly when needed. Palm leaf or cheesecloth shade also is of some help in reducing temperature. As radishes are a short-season crop (3 to 6 weeks), they can be readily intercropped in the row or between the rows of many long-season crops. A row 3 to 4 inches wide can be sown and later thinned so that the plants are spaced about 1 to 2 inches apart and stand 3 abreast in the row. About 5 to 6 feet of row is usually sufficient for family use.

Radishes are commonly grown in beds with coriander for local Puerto Rican markets (fig. 18, *D*). The seeds of the two crops are mixed and broadcast over the bed. The radishes are harvested first, after which the coriander occupies the full space.

INSECTS AND DISEASES.—Radishes do not usually suffer seriously enough from insects and diseases to require spraying. The caterpillar of the white cabbage butterfly, a leaf miner, aphids, and flea beetles may attack the foliage. Deformed, roughened, scaly radishes were noted in gardens in summer near Castañer, P. R.; the disease resembled a minor element deficiency, possibly boron (*46, p. 161*), but the problem was not investigated.

Rhubarb

Rhubarb is grown for the large thick leafstalks or petioles which make excellent sauces and pies. This perennial crop occupies the land the year round and should be placed at the side of the garden. It is relatively resistant to drought. A few plants suffice for the home garden. Although some plants have been grown to medium size at sea level at Mayagüez, growth and quality were better under cool high-altitude conditions (fig. 28, *C*). Good results with rhubarb have been obtained at Toro Negro (3,300 feet) (fig. 3).

In the Tropics rhubarb is usually started from seed. Once established, it may be propagated by crown divisions from an old plant. Seeds are drilled thinly in rows 3 feet apart and covered with about ½ inch of soil. When a few inches high the plants are thinned to about 3 feet apart in the row. Transplanting small seedlings is possible but recovery may be exceptionally slow.

Rhubarb responds well to heavy applications of manure and commercial fertilizer, particularly nitrogen. At high altitudes the plant is dormant in the cold months and should be forced into vigorous growth with nitrogen and irrigation when the temperature begins to rise. Harvest may begin at this time and extend over several weeks.

At low and medium elevations in the Tropics, rhubarb can be treated as an annual or biennial by planting each year the Victoria variety, which has given good results in the southern United States. Soil is well prepared and enriched with manure and a complete fertilizer. The seeds are planted during the cool part of the year and the plants thinned, as previously described. In thinning, the most vigorous plants, including those showing the most reddening of leafstalks, which usually are of higher quality, should be left. Uniform soil moisture should be maintained by irrigation. Side dressings of ammonium sulfate at monthly intervals also help maintain vigorous growth. The outer leaves may be removed when petioles are large enough for use; petioles of the later thinnings also may be used.

Plants are kept growing vigorously throughout the first season, when they are harvested continuously. With the advent of the second dry season the plants are allowed to go into a rest period of a few weeks, after which they are forced into growth by application of water and fertilizer. Not all plants will survive the rainy period or the following dry season. For this reason a new planting is started each year and when it is in production the old planting is discontinued.

Recent research has shown that rhubarb juice, which contains an oxalate, is valuable for reducing corrosion of the teeth caused by excessive acid in lemon juice and cola drinks (*2*).

Insects and Diseases.—This crop is apparently free from insect pests and diseases.

Rutabaga

Rutabaga resembles the turnip, but is larger and more nutritious, and keeps somewhat better under ordinary storage conditions (fig. 28, *D*). Although the temperature range required is the same as for turnip (60° to 70°F.), the rutabaga often grows well at a somewhat lower mean temperature. Good crops were grown in the mountains in Puerto Rico during the cool season, but only fair crops were produced during this season at sea level. During the heavy-rainfall, warm months the roots tend to elongate irregularly rather than to enlarge and are of very poor quality.

Culture for rutabaga is the same as for turnip and carrot, except that rutabaga requires about 5 weeks longer to mature.

Insects and Diseases.—Same as for turnip. Black rot is particularly bad during the warm rainy season. A physiological disease known as brown core caused by boron deficiency, reported in several regions in the Temperate Zone (*46, p. 161*), may appear in the Tropics in areas where this element is lacking.

Salsify (Vegetable-oyster)

Salsify can be grown at all seasons at high altitudes and during the winter at sea level. Leaves of salsify resemble those of leek, but are narrower (fig. 28, *B*). Culture is similar to that of parsnip. The par-

snip-like roots which have an oyster flavor may be used in soups or cooked like carrots.

The seedlings should be thinned to 3 to 4 inches apart in the row. A deep sandy loam soil rich in organic matter is best. Roots in heavy soil tend to be deformed. Salsify required a season of 3½ to 4 months.

Insects and Diseases.—Salsify appears to be free from insects and diseases.

Soybean

The planting of soybeans should be greatly encouraged because of their extremely high nutritive value. Under most tropical conditions this vegetable will produce heavily (fig. 33), particularly when planted

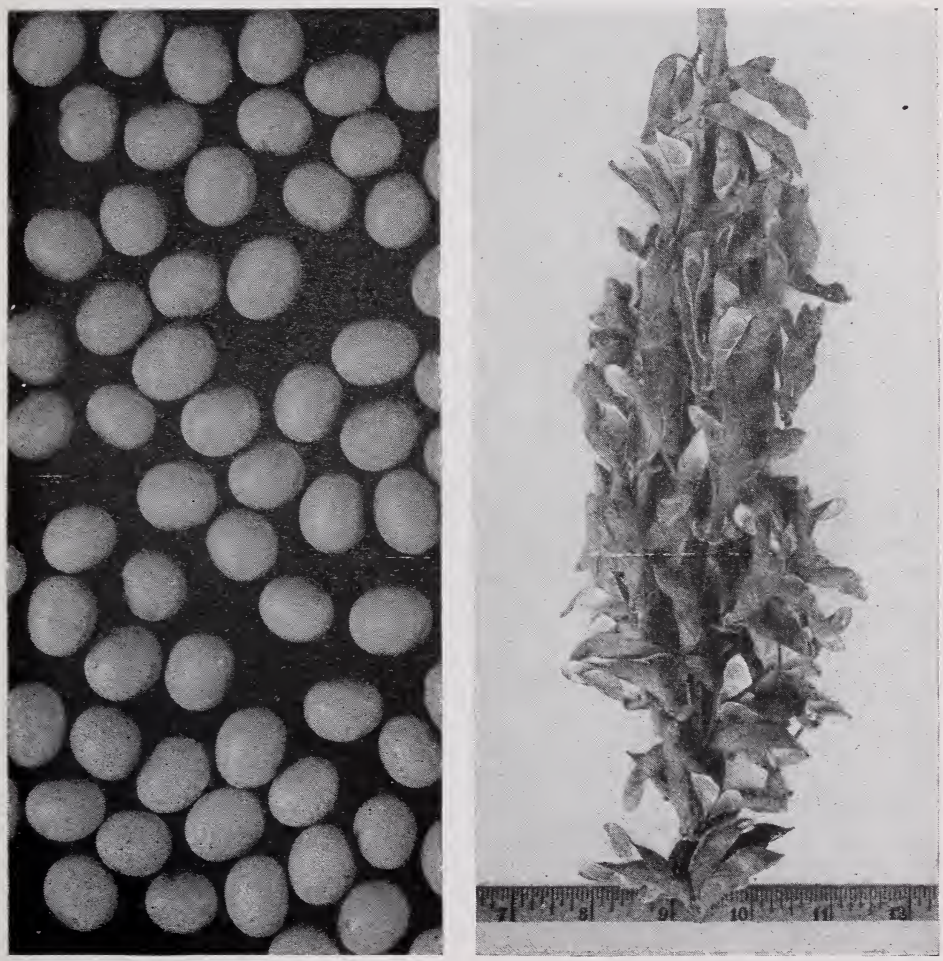


Figure 33.—The nutritious soybean under proper care will produce heavily in the Tropics. Seminole is the variety.

as the days grow longer. The Seminole variety has performed satisfactorily at all seasons at Mayagüez. Growth and production were definitely highest when seeded in February to March.

When planted during the rainy season, soybeans should be seeded on ridges 6 to 8 inches high, 18 to 24 inches apart. Seeds are planted 3 to 5

inches apart in the row. Succession plantings can be made every 3 to 4 weeks, so that a continuous supply will be available throughout the year. A complete fertilizer or ammonium phosphate should be applied before planting, either in furrows on both sides of the seed furrow or 1 or 2 inches beneath the seed furrow. If the soil is very acid, lime should be applied to bring the pH to about 6.5. Irrigation may be necessary, particularly during the early stages of development.

Soybeans are best for eating when cooked like lima beans. The tedious task of shelling can be made easier by dropping the small pods in boiling water for a few minutes, and then dipping them in cool water. The plump seeds can be forced out of the pods by slight pressure between the thumb and forefinger.

Insects and Diseases.—The insects attacking green and lima beans are found on soybeans, but neither insects nor diseases have been a serious factor under Puerto Rican conditions. Pineapple mealybugs, carried by ants, sometimes appear on the roots and lower part of the plants (fig. 34).

Spinach

The true spinach grows poorly in most regions of the Tropics because of too high mean temperatures. Performance was unsatisfactory at Toro Negro and at other places in Puerto Rico. This crop is likely to succeed at altitudes where mean temperatures range from 55° to 65°F. for at least a part of the year. It grows best on slightly acid to alkaline soil. Plentiful manure, water, and commercial fertilizer are needed to produce tender, high-quality foliage.

The Ceylon spinach (Malabar Nightshade), not a true spinach, is vinelike and grows vigorously at sea level in Puerto Rico (fig. 27, *J*). It may be grown from seed or cuttings. About 3 inches of the growing tips are harvested and cooked. When cooked it is not as "slick" as New Zealand spinach. Ceylon spinach grows well with relatively little or no fertilization, but more and better quality foliage can be produced by liberal applications of complete fertilizer, manure, and water. The vines should be trellised to keep the foliage free of dirt.

New Zealand spinach is a good substitute for true spinach at altitudes and temperatures where true spinach does not succeed. It grows satisfactorily throughout the year and seeds freely under Puerto Rican conditions. It is fairly drought resistant. A few plants will produce enough greens for the family for many weeks, provided liberal quantities of fertilizer at planting are followed by monthly side dressings of ammonium sulfate to keep the foliage tender and vigorous. The seed, which should be soaked for 24 hours before planting, is sown in rows 2 to 3 feet apart, and the plants later thinned to about 12 inches apart. About 3 inches of the branch tips and tender leaves are removed for greens. Additional side shoots appear for later use.

The Chinese spinach grows well and rapidly at all altitudes in Puerto Rico. The Tampala variety (*Amaranthus gangeticus*), obtainable from United States seedsmen, is satisfactory. Culture and harvesting are the same as for New Zealand spinach.

Insects and Diseases.—A bronze flea beetle may eat holes in the foliage of Ceylon spinach, but its damage is not serious. A leaf miner and other insects that attack beets may be present on New Zealand spinach. Diseases are usually not a problem.

FIGURE 34.—Infestation of the pineapple mealybug (*Pseudococcus brevipes* (Ckll.)) on crown and roots of soybean. Ants often distribute this and other mealybugs over a number of garden plants.

Sweetpotato

The sweetpotato is an excellent and dependable tropical vegetable for the larger home gardens (fig. 24, *A*). It requires too much space in small gardens except where the vines can be grown on a fence or low

wall. The sweetpotato is a warm-season crop (70° to 80°F.), requiring a growing period of 4 to 6 months. It grows well at sea level throughout the year and at the higher altitudes during the summer, provided the weather is not too cool. Although the ideal soil is a rich sandy loam underlain with clay, this crop can be grown on a wide variety of soils, provided drainage is naturally good or the slips are planted on beds or ridges in areas where soil is a heavy clay and rainfall is abundant. With poor aeration and drainage of the soil the roots will be long and thin and production light. The sweetpotato is one of the most drought-resistant vegetables. Fair crops may be obtained in semiarid districts where most vegetables will hardly thrive. Moderate rainfall, however, is beneficial and irrigation should be provided where available, particularly during the early growing period.

Although manure has benefited the sweetpotato when applied to soils deficient in humus, the general recommendation is to use the available manure on other vegetable crops where the effect on yields will be more pronounced. In fact, fair to good crops of sweetpotato are often obtained in the Tropics without the addition of any commercial fertilizers or manure. Heavy applications of manure or nitrogen fertilizer are not advisable; they produce excessive vine growth at the expense of root development. A complete fertilizer high in phosphorus and low in nitrogen or superphosphate alone are good sweetpotato fertilizers under tropical conditions.

"Totiempo" is a common local variety in Puerto Rico, but its yields are much lower than those from Red Velvet, Mameya, and Porto Morado. Don Juan, another common local variety, gives fair to average yields. Yields of sweetpotato are usually greater when spring planted.

Seed pieces may consist of entire small tubers or cross sections of slender cylindrical roots. Seed pieces from the crown of a plant or the upper part of the root are the most satisfactory. Vine cuttings from mature vines about 12 to 18 inches long can be used for propagation. Also, sprouts or vine cuttings can be obtained by planting tubers in beds at a depth of 3 to 4 inches. Within a month to 6 weeks a number of sprouts should rise from each tuber. These slips are pulled and transplanted with roots attached. Runners or sprouts are transplanted to the field in furrows 4 to 5 inches deep with basal end of the runners down and the tip exposed. Planting distances should be 1 to 1½ feet in rows 2 to 4 feet apart. The 2-foot spacing is desirable on light soil where ridging is not necessary. On heavy soils a 4-foot spacing may be necessary between rows in order to build the ridges high enough. Frequent irrigation should be provided after planting to establish the runners when rainfall is not adequate. Several light waterings are better than a few heavy extended irrigations. It may be wise to wait until a series of rains has started before planting, thus saving the need for irrigation at this time.

Spring-planted sweetpotatoes can be left in the ground for 3 to 4 months or for 5 to 6 months. Tubers will continue to increase in size for several months so long as growing conditions are favorable. Some tubers may be left in the ground during the dry season for storage and later used as seed pieces. If the tubers are harvested during the rainy season one of the best means of storing them is in dry wood ashes (*35, 1937, p. 48*) in a well-ventilated room. Tubers to be stored should be harvested with as little bruising as possible. A storage period of 2 to 4

weeks after harvest is desirable to increase sugar content and eating quality. The tubers should be inspected every few days to make sure that weevils have not started to tunnel through them. The entire stock can be ruined in a short time by this insect.

Under no conditions should the vines be pruned. Marked decreases in yield are likely to result.

Insects and Diseases.—Insects under most conditions do not become a serious problem, although several may cause minor damage. Most plantings are not sprayed. Insects attacking sweetpotatoes are two species of weevils, several small and one large leaf-feeding caterpillars, including the sweetpotato leaf roller (fig. 32, *A*), leaf miner, scale, leaf beetles, and leafhopper.

The only disease of any consequence is black rot which may attack the underground tubers, particularly during wet seasons. The use of tip cuttings from growing vines is recommended where this disease is a problem.

Tomato

The tomato is nutritious and one of the most widely used vegetables produced in the Tropics. Although it will grow at nearly all altitudes in Puerto Rico, the available varieties produce best during the relatively dry season at altitudes lower than 2,500 feet. The minimum and mean temperatures at Toro Negro (3,300 feet) are evidently too low during winter (63° to 65°F.) and rainfall is too abundant in summer to grow good tomatoes. At least, the three popular varieties Pritchard, Pan America, and Marglobe tested there were failures. These results agree in general with those reported in Hawaii at the higher altitudes (*13, p. 88*). A cool, rather dry climate with plenty of sunshine, such as that prevailing in winter near Ponce and Isabela (fig. 14, *B* and *G*) is ideal for tomato production, provided irrigation is available when needed.

Although high summer temperature may be an important factor in reducing yields in the Tropics, particularly of the large-fruited varieties, excessive rainfall is considered at this station to be the most detrimental factor. During summer (80°F.) under greenhouse protection excellent crops of the Michigan State Forcing have been grown here when crops in the field under heavy rainfall were unsatisfactory.

Garden tomatoes may be arbitrarily grouped into three types: (1) The determinate, low-growing, bushy type with each branch ending in a flower cluster and new shoots appearing laterally on the stems; (2) the indeterminate, large-fruited type that grows tall when staked and pruned and sprawling when not staked; and (3) an indeterminate, small-fruited type that produces numerous plum-, pear-, and cherry-shaped fruits.

The determinate varieties that have produced best under Puerto Rican conditions are Pritchard and Bounty. The Pearl Harbor tomato, resistant to spotted wilt virus, is said to be an improvement over Bounty in areas in Hawaii where this disease is a problem (*20*). The determinate type has the advantage of flowering and fruiting early and over a shorter period than the indeterminate types. Under adverse rainy conditions these varieties may set and mature a greater weight of fruits than the large-fruited indeterminate types. Plantings of the determinate type must be made more frequently than those of the indeterminate types, as the determinate plants are shorter lived. The determinate

type should not be pruned. A low supporting framework of bamboo may help to reduce diseases by keeping the foliage and fruits off the ground.

Large-fruited indeterminate varieties that have produced best under field conditions in Puerto Rico are Michigan State Forcing, Rutgers, and Marglobe. The Break O'Day, Valiant, and Stokesdale are also suggested for Hawaii (*13, p. 89*). The Master Marglobe variety is grown widely in the Jayuya district of Puerto Rico (1,500 to 2,000 feet) during the winter (fig. 35). Tests at this station (Mayagüez) have shown that a

FIGURE 35.—Commercial tomato production and packing in the mountain area near Jayuya.

A, Field of Master Marglobe growing on a sandy loam hillside of 40- to 50-percent slope.

B, Wrapping and packing green tomatoes for the New York market.

C, Two brands of tomatoes are prepared, medium- and large-sized fruits.

few of the disease-resistant varieties being developed by the U. S. Southern Regional Vegetable Breeding Laboratory at Charleston, S. C., are definitely superior in yield to the well-known standard varieties under the relatively wet summer conditions at Mayagüez. The first of these varieties, Southland, was introduced in 1948.

The indeterminate small-fruited pear, plum, and cherry types of tomato set heavy crops of fruit under somewhat adverse summer conditions and are not quite so susceptible to attack by insects and diseases. A few of these plants, of which there are several varieties, should be maintained in the home garden to provide fruits when other varieties are likely to fail because of adverse climatic conditions.

There are a few native tomato varieties in Puerto Rico which are more resistant than continental varieties to high temperature and diseases during rainy seasons. The quality of these native varieties is low and the fruits are undesirable because of their knotty furrowed character. Several tropical institutions, including this station, are using the native strains for crossing with high-quality Temperate-Zone varieties to develop superior strains better suited to tropical climates.

Tomato seed is broadcast or planted in rows in well-prepared seedbeds. The seedlings are transplanted to neighboring beds when about 3 to 4 inches high (fig. 18, *C*). At a height of 6 to 8 inches they are transplanted to the garden. Long, leggy plants can be used if their lower sections are laid down in a furrow and only the upper 4 to 6 inches of the tops exposed. Plants are spaced at about 2½ to 3 feet in rows 3 to 4 feet apart, depending upon the tools available for cultivation.

At time of transplanting, 2 tablespoonfuls of a complete fertilizer low in nitrogen and high in phosphorus, such as 4–12–8, should be applied in strips on either side of the plant at a distance of 3 to 4 inches from the base and at a depth of about 3 inches. When fruits begin to set, side dressings of ammonium sulfate at 3- to 4-week intervals will aid in sizing the fruit and keeping the vine vigorous. Frequent cultivation is necessary to loosen the soil and eliminate weeds that may be a source of mosaic and other diseases.

On heavy soil during the rainy season the plants should be set on raised beds or ridges and staked (*35*, *1947*). In the dry season they can be grown on the level and furrow-irrigated if water is available. Where the soil is sandy and the rainfall moderately light, the net returns per acre, it is reported (*38*), are higher without staking and pruning (fig. 14, *B* and *G*).

Staked plants should be pruned to about two main stems and all side branches removed as they appear. This will require visiting the planting every 2 or 3 days. Plants showing mosaic (fig. 36, *D*, *E*, and *F*) should be removed immediately and burned or buried, after which the grower's hands should be washed with soap. It is possible to transfer mosaic from one plant to another during pruning, picking, and other operations. A person using tobacco may be a source of mosaic infection, as tomatoes can be infected with mosaic disease from tobacco. Tobacco users should wash their hands with soap and water before working with tomato plants. Furthermore, they should not smoke or chew tobacco while working with tomatoes.

Fruits in the home garden should be picked when of full size and color. Green tomatoes of good size can be picked and placed on the window sill or in a sunny place for ripening. Commercial tomatoes harvested for shipment are picked when of good size but green (fig. 35). They are packed uniformly by standard procedure (*44*) in medium and large sizes, transported overnight to the seaboard dock, and loaded as soon as possible on a refrigerated ship. Extreme care in handling commercial tomatoes is essential at all times to reduce bruising and subsequent rotting.

Insects and Diseases.—Most prevalent diseases under Puerto Rican conditions are bacterial wilt, leafmold, mosaic, and blight (fig. 23, *G*). A mildew, *Septoria* leaf spot (fig. 36, *C*), anthracnose, and blossom-end rot (fig. 23, *C*) are also factors, particularly when tomatoes are grown successively on the same ground. *Fusarium* wilt, reported in Hawaii

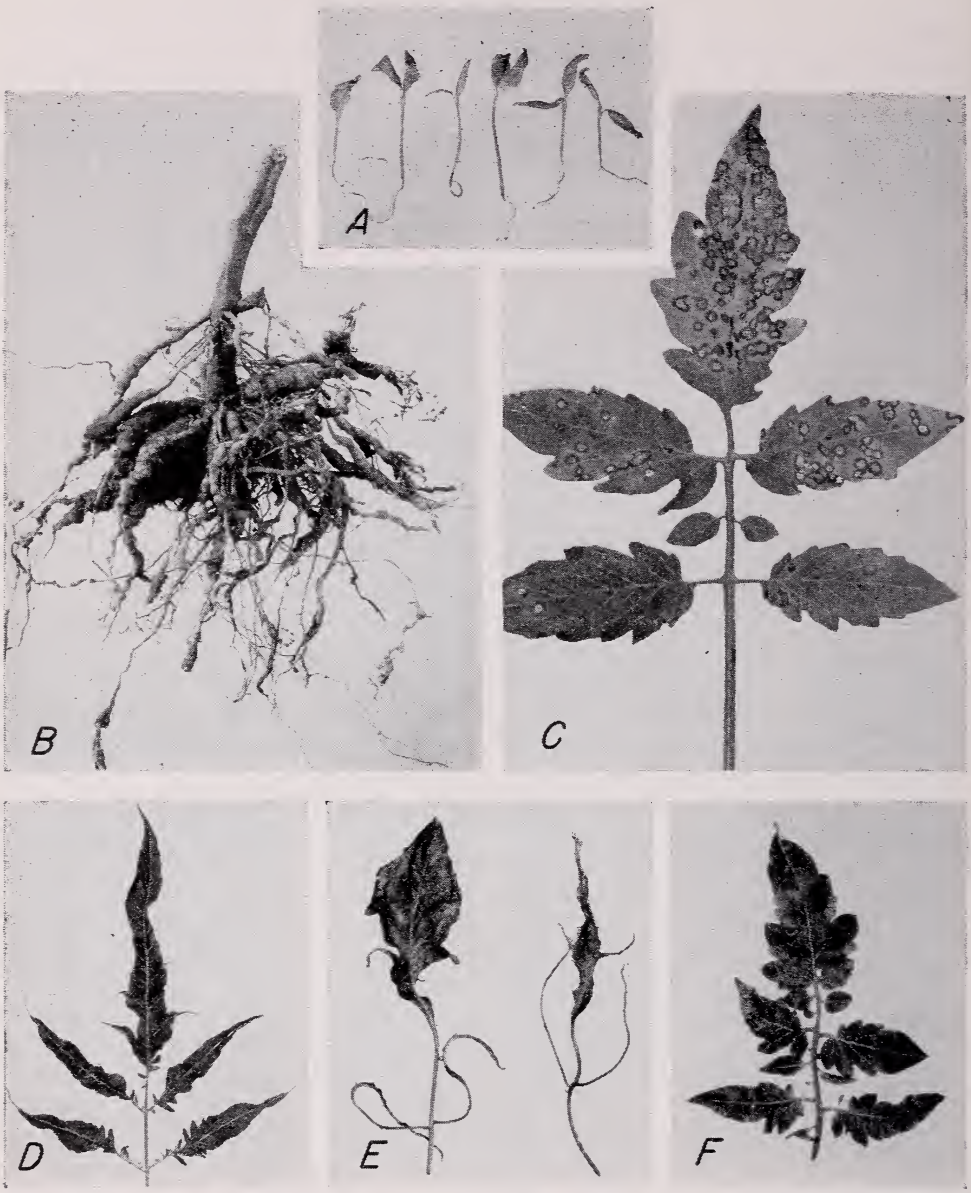


FIGURE 36.—Some common diseases of vegetables: *A*, Damping-off is a common disease with young plants in the seedbed. *B*, Nematode injury on tomato roots. *C*, Septoria leaf spot on tomato. *D*, Fern leaf mosaic. *E*, Shoestring mosaic. *F*, A mottled green (tobacco) mosaic on tomato. (All photos courtesy of U.S.D.A. Bureau of Plant Industry, Soils, and Agricultural Engineering.)

(*13, p. 90*), also occurs in Puerto Rico. Insects and other pests attacking tomatoes include the corn earworm (fig. 37, *C*), flea beetles, and tobacco hornworm (fig. 29, *A*) on the leaves, several species of sucking insects attacking principally the fruit, and nematodes on the roots (*9*).

Turnip

Turnips are widely grown in the Tropics (fig. 26, *C*). Limited quantities are frequently produced for the market. The turnip is less nutritious than the carrot and the tops are not so popular as beet tops for

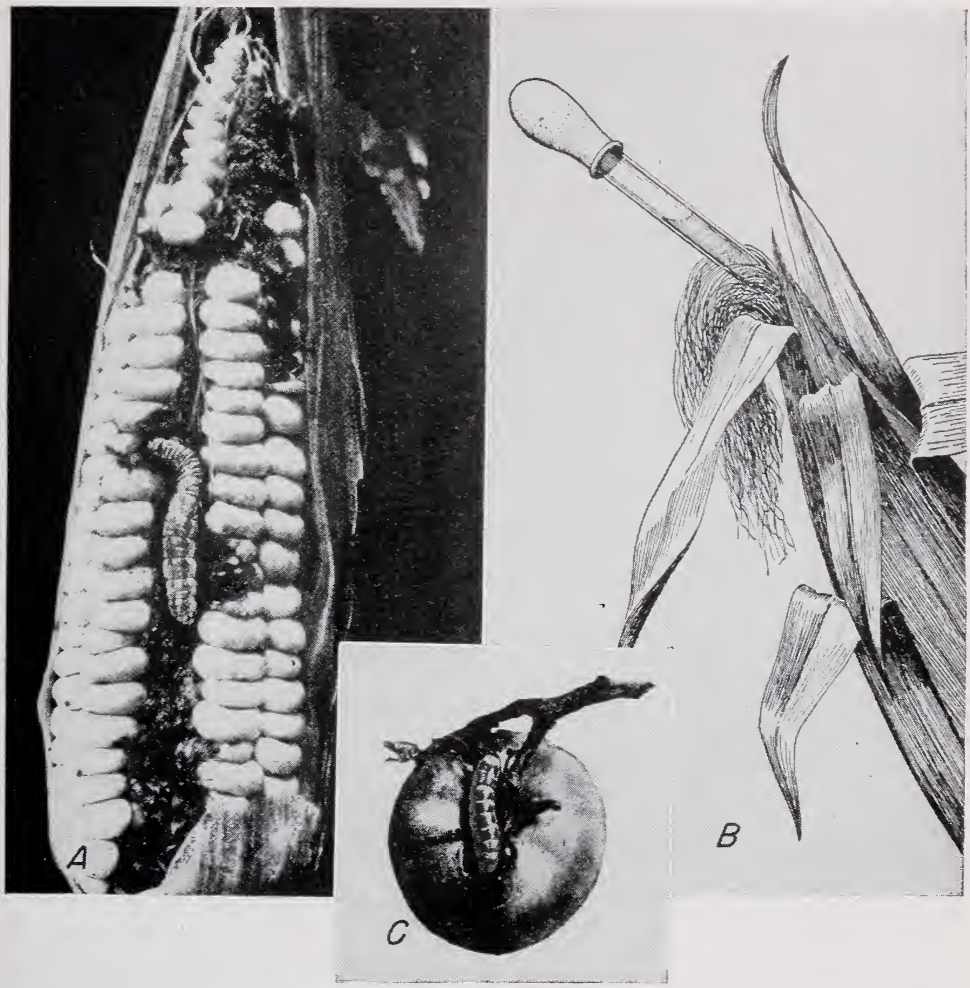


FIGURE 37.—Corn earworm or tomato fruitworm (*Heliothus armiger* Hbn.): *A*, Nearly full-grown caterpillar feeding in ear of corn (*58, fig. 14, p. 18*); *B*, ordinary medicine dropper used to inject mineral oil among silks for earworm control (*56, fig. 11, p. 30*); *C*, caterpillar boring into tomato fruit (*58, fig. 15, A, p. 17*). (*A* and *B* ⅔ natural size.)

greens. Turnips grow best in cool weather at all elevations. Poor crops were grown during the summer at Maricao (2,600 feet), but satisfactory yields were obtained in all months at Toro Negro (3,300 feet). The excessive rainfall at Maricao was apparently the chief limiting factor during the 1945 summer. Varieties such as Purple Top White Globe and Shogoin are recommended. Shogoin tops are better for greens; the Purple Top White Globe is better for roots (*13, p. 76*).

Turnips are planted in the same way as beets and carrots, but they are easier to grow as the seed germinates quickly and the plants grow faster. Turnips respond well to phosphorus and nitrogen; the potash content is usually adequate in lateritic soils of the Tropics. Turnips are harvested when of good size, or about 2½ inches in diameter (fig. 26, *C*). The tops can be removed and used for greens; thinnings of the seedlings can also be used for greens. Rutabaga may be substituted for the turnip at

higher elevations. In fact, rutabagas are frequently sold on the Puerto Rican market for turnips.

INSECTS AND DISEASES.—The same insects that attack cabbage may become pests of turnips, but aphids are often the most troublesome. A leaf spot disease is only of minor importance under good growing conditions.

Watermelon

Although the native home of the watermelon is thought to be tropical Africa, continental varieties of this vegetable are frequently unsatisfactory in the Tropics. Vine growth may be excellent, but fruit set is often light and the fruits are small and low in sugar. Fair to good crops have been reported on sandy loam soil under irrigation near Isabela, P. R. (fig. 30, *A*), and on St. Thomas, United States Virgin Islands (*55, 1932, p. 12*). The Tom Watson variety gave some melons weighing 35 pounds and outyielded the Blacklee by one-third. The Blacklee, however, was sweeter and had darker meat. At Mayagüez, several crops of a number of varieties were grown throughout the year. Vine growth was excellent, but fruit set was light and quality poor. The Philippines have a sizable watermelon industry (*50*). Local varieties include Meck, Valencia, and De Jaspe. Planting season is from October to February, depending on locality. In India (*61, p. 321*) best crops are grown when planted in January and February on gravelly riverbanks where the roots can reach water. A heavy application of manure in the hills is recommended.

Watermelons are not a particularly good crop for the home garden, as they take up a good deal of space for several months and are relatively low in food value. Where plenty of garden space is available, however, the watermelon adds variety and is a good dessert vegetable. Watermelons grow best on well-drained sandy loam soil. They will not tolerate poor drainage and for this reason often fail on heavy soils. They will tolerate a soil acidity of pH 5.0. A commercial fertilizer high in phosphorus, such as 3–12–4, at the rate of 300 to 600 pounds per acre is used, in addition to 2 to 3 shovelfuls of manure in each hill. Well-rotted sugar mill press cake ("cachaza"), which contains a moderate supply of phosphorus, has given good response with watermelons at Isabela. Seeds are planted 6 per hill with hills spaced 10 by 10 feet. The plants should be thinned to 2 or 3 per hill. Cultivation to control weeds is needed until the vines begin to cover the entire area; then the larger weeds are pulled by hand.

Thumping the melon with the finger is a common method of determining maturity. Green melons give a metallic ring, the mature melons a muffled "dead" sound. Two inches of stem should be left on the fruit at harvest.

INSECTS AND DISEASES.—Same as for cucumber.

Yam

Tubers of the true yam (*Dioscorea* spp.) are a highly nutritious food. Among the starchy root crops grown in the Tropics this crop often ranks next to the sweetpotato and yautía in importance.

In habit of growth and cultural requirements the yam is somewhat similar to the sweetpotato; botanically it is not even closely related. It is adapted to a wide variety of soils, but does best in fertile clays and

poorest in light sandy soils. Good soil aeration is essential to good tuber development. For good aeration and drainage the soil is commonly built into ridges from 12 to 18 inches high. First the entire field is plowed; then furrows are opened 4 to 6 feet apart and a few inches of dead vegetable matter, compost, or manure placed in the furrows and covered with 2 or 3 inches of soil. This is followed by another layer of vegetable matter, after which the ridges are covered with soil to the desired height. A chemical fertilizer, such as 5–8–12, may be incorporated in the ridges as they are built. This system may be adapted to the family garden by constructing individual hills in the same way, but spacing them 3 to 4 feet apart.

The crop is planted from late February to May, when soil is in good condition after spring rains. Seed pieces, consisting of the crowns (stem ends) of large tubers, or entire small tubers are planted 1 to 2 feet apart on the ridges and covered with 2 or 3 inches of soil. Spacing depends upon the size of tubers produced by the variety being planted. If the hill method is used, 1 seed piece is planted per hill. Each seed piece should weigh 4 to 5 ounces, to provide sufficient nourishment to give the young plant a good start. Sections of the lower part of the tuber may also be planted, but they are not as satisfactory so the crown. Rotting of the seed pieces may be prevented by dipping them in bordeaux mixture while the cut is still fresh.

When bordeaux mixture is used as a dip, the warning on page 98 should be followed. This mixture is a compound composed mainly of copper sulfate.

The vines should be supported to increase growth and yields. For this purpose bamboo stakes may be used or, in small home gardens, yams may be planted along the fence.

A crop planted in the spring matures in the fall and winter. Tubers may be left in the ground during the dry winter months without deteriorating. In harvesting, care should be taken not to injure the thin-skinned tubers as rot may develop. Tubers intended for seeding the subsequent crop may be left in the ground until planting time.

The yams cultivated in Puerto Rico are of several species and varieties. The most popular yam, known locally as "Guinea," is a variety of *Dioscorea cayennensis*. It is widely distributed over the island, but is best suited to upland clays. The tubers, which often weigh 6 pounds, have white sweet flesh free from fiber. This variety matures earlier than others and the larger tubers may be harvested early, leaving the smaller ones to mature later. Other white-fleshed varieties are Potato, Tongo (*D. aculeata*), and "Agua" (Water) which is a variety of *D. alata*. Purple-fleshed varieties are Purple Ceylon and Mapuey Morado. A yellow-fleshed variety of *D. cayennensis* is known locally as Congo Yellow or Guinea Yellow. It produces better than other varieties in sandy soils.

Insects and Diseases.—Yams are comparatively free from pests. A leaf spot which sometimes attacks the leaves can be controlled with bordeaux 4–4–50. White grubs and grubs of the sugarcane weevil root borer ("vaquita") sometimes attack the roots but are not serious.

Yautía (Tanier) and Malanga (Taro or Dasheen)

The yautías (*Xanthosoma* spp.) and malangas (*Colocasia* sp.) are tuberous plants with large elephant-ear leaves which are common in

gardens throughout the Tropics. On the tuber-producing varieties tubers are two to four times longer than wide and about as big as a medium-size potato (fig. 38). They may be cooked like potatoes or made into soups. Some varieties do not produce tubers, the tender leaves and shoots being the only part cooked or eaten like greens. Both tubers and leaves of the Trinidad dasheen, one of the superior varieties, are eaten. Also, this variety, unlike most of the others, does not have strongly acrid leaves and roots and can be eaten raw. Cooking destroys the acridity in the varieties that should not be tasted when raw.

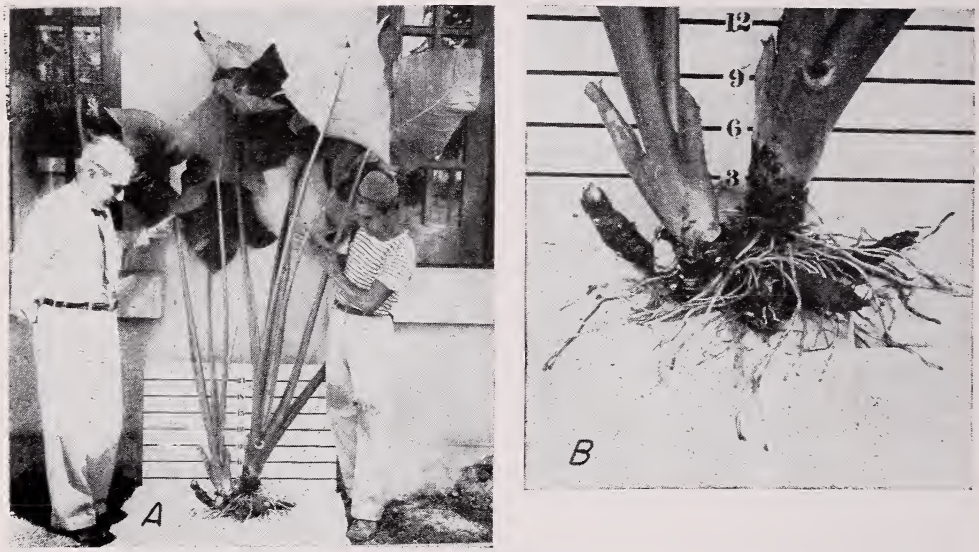


FIGURE 38.—*A*, A yautía (white) plant showing character of growth and tubers. *B*, Developing tubers at the base of the yautía plant; tubers are ready to harvest when white at the tips.

These crops can be grown at all altitudes in Puerto Rico, but they seem to do best at medium to high altitudes in moist regions. Low land around rivers and streams, which is too moist for sweetpotatoes and yams, is well suited to yautías and taros. They will tolerate a wide variety of soils, producing from 7 to 15 tons of tubers per acre.

The top section of the rootstalk, a few inches above and below the ground level, is preferred for planting, although the tubers or any part of the rhizome system having eyes may be used. The tubers or pieces of the rhizomes are set at a depth of 3 to 5 inches and covered lightly with soil; the crowns are set slightly deeper than they grew previously. Best planting period is the cool season between December and April, although plantings may be made at any season if moisture is adequate. Planting distance in soils of average fertility is from 1½ to 3 feet. In fertile soils and with tall growing varieties the planting distance should be somewhat wider. From 8,000 to 10,000 propagation pieces are needed to plant an acre.

A full crop can be harvested within 10 to 12 months. Tubers may be harvested individually as they mature, leaving the smaller ones to enlarge before the plant is removed, or the entire plant may be pulled by hand when the soil is moist and most of the tubers have matured.

Where there are a number of plants of a large variety the plants can be harvested quickly by three men working together. Two men with garden shovels loosen tubers, roots, and soil on one side of the plant; the third man bends the plant to the ground. Some tubers may be left in the ground over the dry season for use as seed the following season.

Insects and Diseases.—Insects and diseases are not major problems. Insects that may be present include a hairy caterpillar, an aphid, a mealybug, the cotton lacebug, and a red spider during dry weather. A smooth black or dark-brown boring caterpillar is the only insect that may become destructive to corms.

Root knot, or nematodes, may be serious in infested soils. A storage rot may occur when corms are stored in damp places.

Other Vegetables and Food Crops

Among the large number of food crops throughout the tropical world that form an important part of the diet of the native populations are the following: Arrow root (*Canna edulis*); topee-tambu or Leren (*Calathea allouia*); a number of legumes, such as bonavist bean or chicharo (*Dolichos lablab*), jackbean (*Canavalia ensiformis*), yam bean (*Pachyrrhizus tuberosus*), winged bean (*Psophocarpus tetragonolobus*), and peanut (*Arachis hypogaea*); horseradish-tree (*Moringa pterygosperma*); *Agati grandiflora*; kafir or cane (*Sorghum* spp.); and several cereal and dry grain crops. Specific recommendations on culture, harvest, and use of these vegetable and food crops are given in MacMillan's book (*26, p. 278*), which is usually available at public libraries dealing with agricultural literature.

COMMERCIAL VEGETABLE GROWING IN THE TROPICS

Commercial vegetable production in the Tropics has by no means reached the degree of proficiency and magnitude that it has in most truck-gardening sections of the Temperate Zone, particularly in the United States. The tropical field is open to expansion in the production of vegetables not only for fresh consumption but also for canning and freezing. Some favored areas—in Cuba, Mexico, Hawaii, U. S. Virgin Islands, and Puerto Rico (figs. 22, 35, and 39)—already have exported at one time or another sizable quantities of fresh vegetables to the heavily populated sections of the United States. These vegetables are grown and shipped principally during the late winter when fresh vegetables are scarce on the continental markets. Vegetables commonly exported to the United States are tomato, pepper, eggplant, cucumber, bulb onion, sweetpotato, cabbage, sweet corn (fig. 40), and the native tropical crops for newcomers to the United States from the Tropics.

Much of the cleared fertile bottom land in the Tropics is already planted to sugarcane, pineapple, banana, cacao, and other well-known tropical crops, but good land there still is not in use or needs to be cleared and irrigated. In fact, some of the land now in major tropical crops might be profitably shifted within limits to vegetables. A sugarcane grower near Ponce, P. R., reported better returns from a few acres of vegetables during World War II than from an equal area of cane. For large-scale commercial gardening, the rich level lowlands are best adapted not only because they are fertile, but also because of ease of irrigation and efficient use of mechanized equipment (figs. 15 and 39).

FIGURE 39.—Harvesting and marketing commercial vegetables by an agricultural company near Bayamón: *A*, Harvesting broccoli in lug boxes. *B*, Washing and packing morning harvest of vegetables for San Juan market. *C* and *D*, General sales room of modern store showing refrigerated self-service dispensing system.

Many areas in the Tropics have a distinct advantage over those in the temperate climates in their 12 sunny months of the year when vegetables can be grown with no frost hazard. Some tropical areas, however, are too rainy and warm for good vegetable production during at least part of the year. Also, their soils may not be particularly well adapted for growing vegetables. Some areas are so far from centers of consumption that the cost of transportation, if available, is prohibitive. At the same time, some parts of the United States are not suited to large-scale vegetable production because of soil, climate, or transportation. Potatoes are grown principally in Maine and Idaho because the climate and soils in those States are specially well adapted to this crop. The sweetpotato is grown chiefly in the South for the same reasons.

The island of Puerto Rico has good, average, and poor areas for commercial vegetable growing. The northwest corner of the island near Isabela, for example, is particularly well adapted to vegetable production throughout most of the year. The land in this area is gently rolling, the soil a well-drained sandy type, rainfall around 50 inches a year, and provision for irrigation good. Commercial crops of eggplant, pepper, tomato, cucumber, and other fresh vegetables already have been grown in this area for shipment to the New York market. The low-rainfall section on the south coast and to the west in the Lajas Valley also is well suited to vegetable production. Sunshine there is abundant almost every day and the soils are of a moderate to good fertility. If irrigation

FIGURE 40.—USDA-34 sweet corn shipped by refrigerated boat from Mayagüez, P.R., to New York City in January, a period when prices are usually good for sweet corn on the cob. Some ears were wrapped in cellophane; all ears arrived in good condition. Such an enterprise might be further developed in the Tropics, also using air freight.

were available in the Lajas Valley, and such a project is contemplated, selected vegetables could be grown throughout the year with relatively little trouble from diseases and other difficulties aggravated by excessive rainfall. Tomatoes are grown commercially during the dry winter months in some of the interior valleys near Jayuya (*3*). The green

tomatoes are packed by a cooperative for shipment to the New York market.

Men with good training and experience in production of specific crops, such as the tomato, bean, pepper, and eggplant, should be able to make a success of this enterprise in many tropical areas. This is particularly true if the prospective grower also has had commercial experience in truck gardening and can effectively utilize modern planting, cultivating, harvesting, and packing materials and machinery. Past experience shows the need for using some mechanized equipment in truck gardening if tropical countries are to compete successfully on a sizable scale with Temperate-Zone growers. This point is stressed because it seems to be one of the main bottlenecks in the progress of tropical agriculture. The hazards of maintaining and operating machinery in the Tropics appear to be no greater than in the United States. True, the high humidity and salt water mist are factors in some areas, but they are probably no worse than the subzero weather, high humidities, and salt water breezes on Long Island, N. Y., where truck gardening has grown into a big industry.

The main difficulty with use of machinery in the Tropics is the frequent lack of regular and efficient operation and poor standard maintenance, such as greasing, oiling, and painting. Also, average to poor labor is often hired to run tractors and machinery, when only industrious, carefully picked well-paid men, should do the job. Also, replacement parts for the machinery are sometimes difficult to obtain. This can be overcome, however, by using equipment from companies doing an export business and having foreign representatives. It is a wise precaution to keep on hand a supply of spare parts and good maintenance equipment as insurance against breakdowns that hold up the work. If the enterprise is large enough to justify two or more tractors, for example, parts may be interchanged if the tractors are of the same make, and at least one tractor can be kept operating while parts for the other are en route. There are a number of such ways to keep an agricultural business operating. Difficulties can usually be surmounted or adjusted if the grower has enough ingenuity.

A frequent objection to the use of mechanized equipment in the Tropics is that it eliminates hand labor, of which there is often an oversupply. This is a normal development, however, in the evolution through which the United States has progressed to attain its present high efficiency and service to the World. Indeed, it is almost impossible to produce vegetables on a large scale with an ox team, hoes, hand sprayers, and machetes.[13] The margin of profit, if any, is likely to be too narrow. Only those growers who can obtain high production of high-quality vegetables, however, will be able to adopt the modern improved production methods.

Many of the recommendations given in this circular for growing vegetables in the home garden can be used for commercial production. Before starting to grow a vegetable on the commercial scale, however, it is important first to be reasonably sure that the crop will *grow and produce*

[13] In the depression year of 1932, in the United States Virgin Islands, it required a little over ½ day to plow and harrow an acre of ground with a 15–30 McCormick-Deering tractor; 2½ days were required with bulls at about double the cost in labor. (Virgin Islands Agricultural Experiment Station, Agr. News Notes 41: 1. 1932. [Processed.]

well under the prevailing climatic and soil conditions and that it can be profitably marketed. Reliable commission agents at importation centers might be consulted as to sales and boat or airplane shipment.

For small gardens of 1 or 2 acres, oxen, mules, and hand labor can be used. On light to medium-heavy soils, the large-wheeled garden tractors (fig. 41) with attachments of plow, disk, seeder, cultivator, and

FIGURE 41.—The large-wheeled garden tractor is well adapted for small areas of 1 to 2 acres. The medium- or light-weight field tractor (right background) with attachments for plowing, disking, cultivating, planting, and power take-off for spraying is a labor saver for vegetable gardens of about 5 to 10 acres. Crawler tractors of similar capacity are also valuable for this size enterprise.

mowing machine are satisfactory. For vegetable gardens of 5 to 10 acres or more, the lighter wheel (fig. 41) or crawler tractor with attachments is desirable. This tractor of about 25 horsepower at the drawbar is usually large enough to plow at least a single furrow in heavy soils and for double disking and cultivating. A power take-off also may be used with it for standard row-crop sprayers. The medium-size crawler tractors are excellent for large-scale heavy plowing and disking. Twenty- to 30-horsepower outfits are adequate for the small to medium-size enterprises. More specific recommendations on the equipment needed for vegetable gardens of different sizes and types can be obtained from representatives of the local experiment stations or colleges and from reputable manufacturers.

When machinery is to be used in planting vegetables, the row spacing must be adjusted to fit the cultivating, spraying, and harvesting attachments. Also, during planting enough space must be left at the end of each row for the tractor to turn around. Machinery can be used on land having up to about 15 per cent slope. Where there is a slight slope, the rows should be laid out on the graded contour, using a carpenter's or engineer's level and target.[14] This is particularly true where rainfall

[14] Where available, get in touch with your local Soil Conservation District for assistance and instructions in laying out the graded contour rows and terraces. Also, there are United States Department of Agriculture publications available in Washington, D. C., on this subject.

is moderate to heavy. Construction of broad-base terraces is advisable on land having a slope between 5 and 15 percent. Bench terraces will be needed for slopes greater than 15 percent, but these are often expensive. The use of contour plantings, with and without terraces, not only preserves the soil but also helps retain rainfall, which is highly essential for shallow-rooted vegetables. Likewise, all cultural operations, including furrow irrigation, are facilitated by contour planting.

Adequate facilities should be provided in or near the field for shading harvested vegetables until they can be washed, graded, and packed (fig. 39). Vegetables never should be left in the sun longer than a few minutes after harvest. Harvesting of most crops can be started early in the morning, but, to prevent spread of leaf diseases in some crops such as beans, it should not be started until the foliage is dry. Some vegetables may be harvested in the afternoon and cooled at night while en route to refrigerated boats.

Proper refrigeration facilities are needed to keep the vegetables in good condition until they can be shipped, canned, or frozen.[15] Low temperatures—32° to 60°F., depending upon the vegetable (*51, p. 171*)—are extremely important in retarding ripening and deterioration. For roughly every 10-degree rise in temperature above 32°, the rate of ripening is doubled and the storage life reduced by one-half.

In conclusion, it should be pointed out that more attention, equipment, materials, and better-trained labor are required for commercial crops such as beans and tomatoes than for such easily grown crops as plantain, yautía, and pigeonpea. The manager must be "on the job" almost every day. Planting, spraying, cultivating, and harvesting must be done and *thoroughly supervised* at the right time to make the enterprise an economic success.

VEGETABLE GROWING BY GRAVEL CULTURE

During World War II a few United States Army bases were built where there was neither soil nor rain water. The soil around other bases was so heavily infested with human disease organisms that vegetables for troop consumption could not safely be grown in it. This problem was solved in barren Ascension Island, in British Guiana (fig. 42, *B*), in Japan, and in other areas by using the gravel culture system, known as nutriculture (*1*), hydroponics, and chemical gardening. Some of these gardens called for a sizable financial investment and several acres of land. In Japan, where cold temperatures were a factor in winter, the gardens were established under glass. For varieties used in Curaçao, see Mullison and Mullison in Additional References section, p. 143.

The gravel-culture method of growing vegetables has several advantages, particularly in tropical regions, where the beds can be used almost every month of the year. Once the beds and pumping system are established, several common vegetable-growing practices—plowing, disking, weeding, and composting—can be reduced or eliminated. Insect and disease control measures also are frequently reduced or simplified. Excess moisture around the roots—definitely a problem in heavy rainfall

[15] Consult the large refrigeration companies in the United States for specific recommendations on cost and construction of storages and size of equipment needed. Supply necessary figures on kind and size of crop, rate of loading, outside temperatures, and length of storage period.

FIGURE 42.—Growing vegetables by gravel culture:

A, Michigan State Forcing tomato grown in gravel culture in Puerto Rico.

B, Cucumbers grown in a large gravel culture garden at the U. S. Army base in British Guiana.

C, Solutions must be checked once or twice a week to maintain proper levels of the different nutrient elements. Note time clock at upper left which actuates nutrient solution pumps three times daily.

D, Michigan State Forcing tomato plants grown in greenhouse benches in Puerto Rico; (left) in gravel culture, (right) in topsoil to which manure and commercial fertilizer have been added.

tropical regions—is not a factor with properly managed gravel-culture beds. Rain falling into the beds is bypassed in the drainage system, so that is does not dilute the nutrient solution stored in the tanks. Supervision and management of gravel-culture benches, however, must be of high quality. The operators should have some training in chemistry as well as in practical gardening. Periodic checking of the nutrient solution (fig. 42, *C*) is necessary to maintain proper acidity and to bring the nutrients up to standard levels.

The chief disadvantage of the gravel-culture system is the initial expense of installing the beds, solution tank, and other specialized equipment, such as time clock, solution pumps, solution-testing equipment, and gasoline or electric motors. This system of growing vegetables is probably best adapted to areas where it is difficult to grow them by other means.

At Mayagüez, P. R., two crops of Michigan State Forcing tomatoes (fig. 42, *A* and *D*) and Slobolt leaf lettuce were grown by the gravel-culture system under greenhouse conditions.[16] In 1946–47 the yield of tomatoes was definitely better than that from a neighboring bench of local river-bottom soil given standard applications of chemical fertilizers. Growth and quality of leaf lettuce were satisfactory in both the soil and gravel.

Raised concrete beds with solution tanks beneath were used in these trials, but slightly sunken ground beds of concrete, asphalt, or possibly aluminum are more economical and equally as satisfactory. A number of parallel ground beds can be fed with solution from a single reservoir tank, supplied through a trough running at a right angle to the beds. The beds can be any length up to about 100 feet. A bench width of about 4 feet facilitates crop management. Walks between beds should be of rock or asphalt to reduce splashing of soil and disease spores onto the plants.

A complete description of the equipment and technique for growing vegetables by gravel culture would require too much space in this publication. For details the reader is referred to the literature cited at the end of this circular (*1, 22, 49, 60*).

DISEASE AND INSECT CONTROL

Precautions to be Taken With Fungicides and Insecticides

In handling, mixing, and applying poisonous fungicides and insecticides, special care should be taken not to inhale dusts or sprays at any time. Well-designed respirators that afford protection to the entire face should be kept handy and used when such danger exists. After working with insecticides, the hands or any other exposed parts of the body should be washed thoroughly with soap and water.

Containers in which these materials are kept or stored should be plainly labeled and placed under lock and key, or at least out of the reach of children and others unfamiliar with their poisonous nature. Any unused portions of these poisonous preparations as well as the receptacles in which they have been mixed should be treated likewise.

Experience and careful observation have shown that if the poisoned baits mentioned herein are prepared and applied according to directions, their use will not be hazardous to domestic animals. Surplus poison bait should be destroyed.

In the preparation of garden crops for human consumption, vegetables, particularly those to be eaten raw or as greens, should be washed as a health and sanitary measure.

Warning Regarding Poison Residues

Unless the poison residues can and will be removed by washing or stripping, any spray, dust, solution, or bait that contains such materials as lead arsenate, calcium arsenate, paris green, cryolite, barium fluosilicate, sodium fluosilicate, tartar

[16] Authors of this circular are indebted to Héctor R. Cibes, collaborating agronomist, Federal Experiment Station, for information given in this paragraph.

emetic, and compounds of mercury, DDT, or benzene hexachloride should not be applied when foliage or fruit that is intended to be eaten is on the plants.

All insecticides or other chemicals should be applied as sparingly as is consistent with the control of the insect or the disease that is being combated. When spraying or dusting, every effort should be made to apply a light, even coating and to avoid unnecessarily heavy applications.

Diseases

Diseases found in the vegetable garden fall into five groups: Fungus, bacterial, virus, physiological, and those caused by nematodes.

Diseases Caused by Fungi and Bacteria.—Fungi and bacteria are probably responsible for more damage in the garden than any other disease agents. The leaf spots, blights, and wilts commonly found on tomato, beet, eggplant, carrot, and melon are examples. Diseases of this sort are most effectively controlled by bordeaux mixture, the fixed copper fungicides (basic copper sulfate, copper oxychloride, copper oxychloride sulfate, and cuprous oxide), or in some cases by the newer organic compounds, such as Zerlate, Fermate, and Dithane, used with zinc sulfate and lime. The wettable sulfurs are generally much less effective except for control of rusts and powdery mildews. Sulfur cannot be used on the cucurbits—cucumber, muskmelon, squash, and pumpkin—because at high temperatures it frequently causes leaf burning.

Plants receiving enough water and fertilizers may sometimes wilt and eventually die. Several bacteria and fungi are responsible for this. They usually enter through the root and spread internally through the plant's vascular system. Among the plants frequently affected are tomato, pepper, and eggplant. Sprays are of no value because the fungus or bacterium causing the disease is internal and cannot be reached by the fungicide. Use of resistant varieties and rotation with unsusceptible crops are advisable. Seedbed soils can be freed from wilt-producing organisms by treatment with steam, formaldehyde, or chloropicrin (pp. 100–101), but these treatments are too expensive for use in the field.

Virus Diseases.—Virus diseases are identified by a number of different symptoms, the most common of which are a light-and-dark-green mottling of the foliage, frequently seen on the growing points of the tomato (fig. 36, *F*), and dwarfing and leaf curling, seen on melon leaves. Other symptoms include small narrow leaves having a fern-leaf or shoestring appearance (cucumber mosaic), also seen at the top of tomato plants (fig. 36, *D* and *E*). In another type (spotted wilt) the tops die back quickly, giving the appearance of having been singed with a blowtorch.

Virus diseases are transmitted by any means that brings a minute quantity of infected sap in contact with a slight wound in a healthy plant. Viruses are commonly transmitted from plant to plant by handling, pruning, or brushing against the plants, and by cultivation equipment. They are also transmitted by aphids, leafhoppers, or other insects that carry minute amounts of infected sap after feeding on a diseased plant. Weeds also may harbor virus diseases that can be transmitted to healthy plants by insects or mechanical means. Fortunately, most of the viruses affecting vegetables are not carried on the seed, green beans being a notable exception.

Virus diseases are difficult to control once they appear on cultivated crops. Every effort should be made to prevent infection of seedlings before transplanting and to delay or prevent infection in the field. The control of weeds is highly important, as they are a common source of infection. Contact insecticides will greatly reduce the number of insect carriers and may aid in preventing infection. Plants showing the symptoms of virus diseases should be removed immediately and burned or buried and hands or tools used for the job washed thoroughly with soap before again working with healthy plants. This is particularly important with tomatoes. The virus of ordinary tomato mosaic also infects tobacco and is present in the dried leaves and the manufactured product. Workers who use or handle tobacco are likely to carry the virus on their hands and thus infect tomatoes. The best means of virus disease control is the use of resistant varieties. As yet, however, we have resistance to only a few such diseases. Several varieties of green beans resistant to a common bean mosaic and some varieties of mosaic-resistant cucumbers have been introduced.

Physiological Disorders.—Physiological disorders may be brought about by lack of essential elements in the soil, excessive irrigation, drought, or poor cultural practices, such as use of the wrong fertilizer or improper placement of fertilizer near the plants which causes leaf and root burning. Some physiological disorders in tomato are shown in figure 23, *C*.

Root Knot Nematodes.—Nematode injury, occasionally seen in gardens, is characterized by dwarfed, yellowed tops and swollen, knotty roots. Plants fairly susceptible to nematodes include broccoli, Chinese cabbage, cabbage, cucumber, onion, sweetpotato, and turnip. If the soil becomes infested with nematodes it is extremely difficult to eradicate them under tropical conditions. Highly resistant crops, such as corn, might be grown for 2 or 3 years on infested plots, or the soil might simply be plowed and left fallow (free of any crop, including weeds). Treatment with a soil fumigant, such as D-D mixture, is probably one of the most immediate and best methods of eliminating nematodes from the soil. The recommendations of the manufacturer should be followed. Chloropicrin also can be used, but the cost may be a little high, and its use calls for special equipment and consultation with someone familiar with its application. Chloropicrin also gives effective control of parasitic fungi and bacteria in the soil, being superior to D-D for this purpose.

Control Measures.—For practical purposes, measures for the control of diseases that attack vegetables fall into three groups: Soil treatments for seedbeds, seed treatments, and treatment of vegetative parts.

Soil treatments are generally aimed at the suppression of soil-inhabiting organisms, chiefly those of fungus and animal origin, that affect seedlings. The classical treatment using steam or dry heat will be satisfactory for most gardens, especially small ones. The use of steam requires a boiler of a type that is usually difficult for the average farmer to obtain. Soil intended for the seedbed can be heated on iron sheeting over a fire, heat being applied continuously for 15 to 30 minutes. The soil should be sprinkled with water before applying the dry heat (p. 44).

Formaldehyde solution (1–50 dilution) is fairly satisfactory in soil disinfection. It gives good control when applied at the rate of ½ to 1 gallon per square foot of soil surface. For best results the soil for seedbeds should be very loose. The soil surface should be covered with burlap

sacks, duck cloth, or similar material as soon as the soil is drenched with the formaldehyde solution. The covering is removed after 24 hours, and when the soil is sufficiently dry it is kept stirred to hasten the escape of the formaldehyde vapor. Seed is usually sown at the end of 5 to 7 days, but beds should not be planted if there is a strong odor of formaldehyde in the soil. Formaldehyde is toxic to living plants and should not be used where there is danger of the fumes reaching cultivated plants nearby.

Bordeaux mixture (4–4–50) applied at the rate of ½ gallon per square foot of seedbed soil surface gives control of damping-off. Its effects are more lasting and seem to offer some protection to seedlings.

Several new products now on the market—including Fermate, Dithane, and calcium dimethyl dithiocarbamate—when dusted over the seedbed soil and raked in thoroughly, give good control of the pathogenes causing damping-off of seedlings. The manufacturer's recommendation should be followed.

Soil fumigants effective against nematodes in roots are Larvacide (chloropicrin), Dowfume G, ethylene dibromide, and D-D mixture (1,3-dichloropropylene and 1, 2-dichloropropane).

Seed treatments are used to protect seedlings during emergence against decay caused by soil fungi. They are also used as disinfectants to destroy disease-producing bacteria and fungi on seeds. Dusting seeds with organic mercury or other compounds or soaking them with liquid fungicides, such as calcium hypochlorite, are eradicatory treatments. Treating vegetable seeds with Ceresan (wet or dry), New Improved Ceresan, Spergon, Arasan, Semesan, or cuprous oxide will protect young seedlings from soil pathogens. All these chemicals should be used as recommended by the manufacturers. Copper fungicides should not be used on seeds of cabbage and related crops. Spergon or Arasan is safest for lima beans.

In treatment of vegetative parts, plants may be either dusted or sprayed for the control of important diseases. Bordeaux mixture (4–4–50) remains a good fungicide for many of the diseases affecting the foliage, stem, and fruit of vegetables. This mixture is made by dissolving separately 4 pounds of copper sulfate and 4 pounds of fresh burned lime each in 5 to 10 gallons of water, then mixing the solutions and adding enough water to make 50 gallons. Metal containers should not be used. The fixed copper compounds (p. 99) make nearly as effective fungicides as bordeaux mixture and are less injurious to tomatoes, cucumbers, and other vegetables. They, rather than bordeaux mixture, are specially advisable for young tomato and cucumber plants. They can be applied as either sprays or dusts when mixed with an inert carrier.

Fermate is often used to control bean and tomato anthracnose and potato diseases. Dithane, combined with zinc sulfate and hydrated lime (1.5–1–0.5 pounds in 100 gallons of water), has given outstanding results in the control of late blight on tomato and potato foliage and is effective against some other foliage diseases of these vegetables. Recent work shows that Dithane, Zerlate, and Fermate are slightly superior to the copper fungicides in the control of certain diseases and are generally less likely to injure the plants.

Besides the direct application of fungicides, there are a number of practices that should be followed to control diseases of vegetables: (1) Control weeds by regular cultivation and hoeing; (2) keep the plants in a

vigorous growing condition by judicial irrigation and fertilization; (3) keep all insects under control (many carry virus and other diseases); (4) select disease-resistant varieties when available; (5) burn or bury all plants showing virus diseases as soon as found; (6) remove vegetable plants immediately after they have served their purpose (insects and diseases accumulate on these plants to become troublesome to neighboring healthy plants); (7) rotate crops from one area of the garden to another; (8) provide good soil drainage from the outset; (9) keep the plants properly thinned (foliage of overcrowded plants dries slowly after rains and provides good conditions for spread of fungi and bacteria); (10) water seedbeds in the morning to reduce or control damage from damping-off disease; (11) remove, bury, or burn all plant refuse around the garden; (12) do not work the soil or harvest crops like beans when the plants are wet.

To control fungus diseases, as well as insects, it is important to note their appearance as early as possible and apply control measures immediately. Every plant or portion of a plant that is heavily diseased should be removed before spraying a crop. Where a tomato or other crop is known to become infected regularly with leaf diseases, it is wise to carry out a standard program of spraying as a preventive measure. Once the disease has become well established it is often too late to accomplish much by spraying.

COMMON VEGETABLE DISEASES IN THE TROPICS

Table 11 lists the diseases that are common to vegetables in the West Indies and other tropical areas. Although this list by no means includes all the diseases occurring throughout the Tropics, it does give leads as to how the different types may be most effectively controlled. Agricultural experiment stations in many tropical regions, as, for example, Hawaii (*13*), the Philippines (*50*), and India (*62*), can be consulted for identification and methods of control of diseases causing particular concern and not described here. Additional information on vegetable diseases in the Antilles may be found in Cook (*7*).

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control*[1]

CABBAGE, CHINESE CABBAGE, KOHLRABI, RUTABAGA, BROCCOLI, COLLARD

Disease	*Symptoms*	*Control*
Black rot (*Pseudomonas campestris*).	Plants dwarf, leaves turn yellow and brown; veins become black. Entire head decays into an odorous mass.	Avoid successive plantings on same ground. Use disease-free soil in seedbeds, or disinfect soil. Destroy diseased plants as soon as possible. As the bacteria can be carried in, as well as on, the seed, surface disinfection will not free seed of black rot infection. Seed grown on the Pacific Coast of the United States is free from black rot.

See cautions on pages 31 and 98 on the use of chemicals.

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control* [1]—Continued

Disease	*Symptoms*	*Control*
Blackleg (*Phoma lingam*)	Brown depressed cankers on stem near soil surface. Circular light-brown spots may appear on leaves.	Rotate members of cabbage group with other vegetables. Control weeds belonging to cabbage family. As the fungus is commonly carried inside the seed, follow directions for obtaining disease-free seed under "Black rot."
Downy mildew (*Peronospora parasitica*).	White mold on under side of leaves during cool cloudy weather.	Use bordeaux or copper oxide preparations on young seedlings in seedbed. Spray or dust seedlings with Spergon or spray with Dithane plus zinc sulfate and lime.
Mosaic (a virus disease found mostly on leafy cabbage).	Light and green mottling of leaves.	Rotate crop. Control aphids and weeds.
Damping-off (*Pythium debaryanum* and *Phytophthora parasitica*).	Rotting of seedlings at soil level (fig. 36,*A*).	Drench soil with bordeaux, formaldehyde, Spergon, Fermate.
	TOMATO, EGGPLANT, PEPPER	
Virus diseases (several types).	*Mosaic* causes mottling of leaves with light- and dark-green areas, showing some puckering (fig. 36, *D, E, F.*) *Spotted wilt* may cause the growing point of plant to wilt suddenly, darken, and die. There is a bronzing of the upper leaves, with some round spots.	Control insects, particularly sucking types, such as leafhoppers and aphids. Control weeds. Remove affected plants immediately and burn. After handling diseased plants, wash hands with soap before touching healthy plants. Rotate from one area to another in garden. Use resistant varieties.
Bacterial wilt (*Phytomonas solanaceara*).	Plants wilt in middle of day and may recover overnight. Wilting becomes progressively worse until plant dies.	Sprays and dusts of no value, as bacteria attack through roots. Rotate crops, omitting pepper, eggplant, and potato as successive crops. Use resistant varieties.
Septoria leaf spot (*Septoria lycopersici*).	Spots develop largely on under side of leaves near soil surface and later spread to most of the foliage; development most rapid during rainy humid weather. Dots or grayish mold on under surface of leaves (fig. 36, *C*).	Spray with tri-basic copper sulfate, bordeaux, or cuprous oxide, or dust with tri-basic copper sulfate or copper lime dust.
Early blight (*Alternaria solani*).	Spots on leaves, developing concentric rings, with characteristic brownish color. Similar spots on stems can attack fruit at stem scar. Develops rapidly in wet weather.	Spray with bordeaux, tri-basic copper sulfate, Zerlate, or cuprous oxide, or dust with cuprous oxide, copper lime, tri-basic copper sulfate, copper oxychloride sulfate, or Zerlate.

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control* [1]—Continued

Disease	*Symptoms*	*Contro*
Late blight (*Phytophthora infestans*).	Large water-soaked areas appear on leaf margins. Mildewlike white growth on under side of leaves. Leaves may turn brown and dry rapidly. Development is fast during cool moist weather (fig. 23,*G*).	Spray with bordeaux 5–5–50 at weekly intervals.
Damping-off	Same as for cabbage.	Same as for cabbage.
Fusarium wilt	Attacks roots, causing plant to wilt and eventually collapse. Stems show darkened areas near surface.	Rotate tomato crop. Use resistant varieties. Sprays and dusts of no value.
Leaf mold (*Cladosporium fulvum*)[2]	Olivaceous areas on lower surface of leaves, yellow discoloration on upper surfaces. Causes defoliation. Very severe.	Bordeaux or organic fungicides must be applied to lower surface of leaves.
Cercospora leaf spot (*Cercospora capsici*).[3]	Yellowish-brown spots on leaves, with concentric rings, white centers.	Spray with bordeaux or copper oxide. Dust with copper lime, copper oxide, Zerlate, or Fermate.
Fruit rot (*Phomopsis vexans*).[4]	Leaf spot and fruit rot. Severe in Puerto Rico.	Bordeaux or Zerlate.
Anthracnose (*Glocosporium melongenae*[4] and *Colletotrichum phomoides*).[3]	Fruit spots and rots. Severe, especially during rainy weather.	Spray or dust with Zerlate or Fermate. Copper sprays are less effective.
Blossom-end rot (a physiological disorder associated with water supply).	Blossom end of fruit showing small to large sunken, dark-brown or black areas. (fig. 23,*C*).	Provide a uniform soil moisture supply. Sprays and dusts of no value.
Nematodes	Minute worms in roots, causing bulging, knotty roots (fig. 36,*B*).	Use nematode-free soil. Disinfect soil with fumigants, such as D–D or chloropicrin. Dusts and sprays of no value. Rotate with unsusceptible crops.
	POTATO	
Late blight (*Phytophthora infestans*)	Large water-soaked areas on leaves or stalks. Mildewlike white growth on under side of leaves. Leaves may die and turn brown rapidly. Development is rapid during cool moist weather. Tubers may be attacked before and during harvest, causing irregular brownish areas on skin and in flesh.	Spray with bordeaux, a basic copper, cuprous oxide, Dithane, or Parzate, or dust with a basic copper, copper-lime, Z78, or Parzate.
Bacterial wilt or brown rot (*Phytomonas solanaceara*).	Plants wilt only during hottest part of day at first; later, wilting becomes severe and plant dies. Brown areas develop in stems, roots, stolons, and tubers. Bacteria ooze from cut parts.	Plant disease-free seed of more resistant varieties, such as Katahdin. Disease partially controlled by use of sulfur in summer and lime in fall.

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control* [1]—Continued

Disease	*Symptoms*	*Control*
Virus diseases (leaf roll, mild mosaic, rugose mosaic, spindle tuber).	Rolling of leaves and lighter shade of green; mottling and crinkling of leaves; stunting of plants; slender upright growth with darker green foliage. Tubers spindle-shaped.	Use certified seed. Control insects, especially aphids.
Rhizoctonia canker, or black scurf (*Corticium solani*).	Sprouts die before they emerge; side branches develop and may also have their tips killed. Brown cankers form on sprouts and stolons. Leaves often roll; small potatoes form in axil of leaves. Hard, black bodies adhere to skin of tubers.	Use disease-free seed in clean soil. Disinfect badly diseased tubers by dipping in organic mercury compound or soak for 1–2 hours in mercuric chloride (corrosive sublimate) solution, 4 ounces in 30 gallons water. Do not use a metal container.
Scab (*Actinomyces scabies*).	Circular or irregular corky areas develop on surface of tuber. Also pits may develop on tubers. Usually less severe in acid soils.	Use certified, disease-free seed or plant in uninfested soils. Treat infected seed as for Rhizoctonia.
Early blight (*Alternaria solani*).	Relatively small brown spots on leaves. Characteristic concentric rings develop a target pattern.	Same as for late blight plus Zerlate, or Karbam White as spray or dust.
Bacterial ring rot (*Phytomonas sepedonica*).[5]	Stems wilt with mottling of leaves. Bacteria ooze from cut stems and vascular area on stem end of tubers. Tubers decay rapidly in hot weather.	Use certified seed. Disinfect all equipment and containers used to handle potatoes.
Wilt (*Fusarium lycopersici*; or *Verticillium alboatrum*).	Plants wilt slowly or suddenly, depending on climatic conditions. Stems show darkened areas near surface. Lower leaves may turn yellow and fall off.	Plant disease-free seed and rotate crop with plants other than tomato or pepper.
LEGUMES, INCLUDING LIMA BEAN, SOYBEAN, COWPEA, EDIBLE PODDED PEA		
Anthracnose (*Colletotrichum lindemuthianum*).	Pods, stems, and seed exhibit brownish sunken spots. Veins of leaves may turn black.	Do not plant seed from infected plants. Do not cultivate or pick beans when foliage is wet in early morning or after rains. Spray at 10–15 day intervals with Zerlate, Dithane plus zinc sulfate and lime, and Phygon. Bordeaux mixture 4–4–50 may give some control, but is less effective than the organic fungicides mentioned.
Mosaic	Leaves show mottling in color, and crinkling and puckering, caused by a virus carried by leafhoppers and other sucking insects.	Control leafhoppers with DDT. Control weeds and destroy diseased plants immediately. Use disease-free seed or resistant varieties.

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control* [1]—Continued

Disease	*Symptoms*	*Control*
Powdery mildew	White powdery moldy areas on leaves.	Dusting or spraying with sulfur, bordeaux mixture, or copper oxide may help check disease.
Rust (*Uromyces appendiculatus*).	Raised reddish dots on stems, leaves, and pods.	Common bush green bean varieties are usually resistant. Dust or spray with sulfur, beginning when plants are young. Use resistant varieties.
CUCURBITS (CUCUMBER, CHAYOTE, MELON, PUMPKIN, AND SQUASH)		
Mosaic	Mottled light and dark green areas on leaves; some puckering and crinkling of leaves, usually starting near growing point.	Use resistant varieties. Control leafhoppers and aphids. Eradicate weeds from garden and adjacent land.
Downy mildew (*Pseudoperonospora cubensis*).	Angular yellow spots on leaves, causing them to die. Interferes with fruit set and development. Aggravated by wet weather.	Use resistant varieties, such as Puerto Rico No. 39, and spray with bordeaux mixture 2–2–50 before flowering, 3–3–50 after fruit set.
Anthracnose (*Colletotrichum lagenarium*).	Light yellow spots on leaves, which eventally turn black. Spots are dark and sunk in the fruit.	Spray as for downy mildew before flowering, but use 4–4–50 bordeaux after fruits are set. Destroy diseased fruits.
Leak (*Pythium aphanidermatum*).	Fruits rot in field or during shipment, exuding juice.	Remove from containers all fruits showing signs of the disease.
CARROT		
Leaf spot (*Cercospora apii carotae*).	Brownish spots on leaves. Tops may be completely destroyed, but reappear and a good crop is produced.	Apply cuprous oxide or bordeaux spray at 10-day intervals, particularly during rainy weather, after disease has appeared. Furrow irrigate where possible.
Soft or root rot (*Bacillus carotovorus*).	Outer part of roots affected.	Use raised beds in wet areas and provide good drainage and spacing of plants. Rotate crop where possible.
CASSAVA		
Leaf spot (*Cercospora henningsii*).	Subcircular to irregular gray or white spots with dark-red borders. Damage usually insignificant.	----------
Rust (*Uromyces janiphae*).	Dark pustules on under side of leaves. Rarely seen.	----------
CELERY		
Late blight (*Septoria apii*).	Circular yellow spots on leaves, which later turn brown with tiny black specks.	Spray with copper oxide, bordeaux mixture 4–4–50, or wettable sulfur at 10-day intervals, or dust with copper oxide, bordeaux or sulfur. Use furrow irrigation where possible.

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control* [1]—Continued

Disease	*Symptoms*	*Control*
Early blight (*Cercospora apii*).	Yellow-grayish spots without black specks.	Do.
Blackheart (physiological disorder occurring in warm, wet weather).	Leaf margins show brownish and black discoloration, particularly on young leaves in the heart.	Avoid excess irrigation. Dusting and spraying of no value. Maintain uniform soil moisture.
Soft rot (*Bacillus carotovorus*).	Soft decay at base of plant.	Destroy diseased plants immediately. Rotate crop.
	CORN	
Smut (*Ustilago zeae*).	Distorted kernels filled with black powdery spores.	Plant clean seed. Rotate crops.
Leaf spot (*Helminthosporium turcinum*).	Dark elongated spots which may spread and kill leaves.	Use USDA-34 sweet corn or other resistant varieties.
Mosaic	Mottled light and dark green areas on leaves.	Use resistant varieties, such as USDA-34.
Rust (*Puccinia sorghi*).	Dark powdery pustules on leaves.	No control usually necessary.
	LETTUCE (HEAD AND LEAF)	
Leaf spot (*Alternaria* sp. and *Macrosporium* sp.).	Leaves show small round brown spots with purple and red borders.	If serious, spray with cuprous oxide or bordeaux mixture, repeating at weekly intervals. Dust with cuprous oxide, bordeaux, or copper lime. Allow plenty of space between plants. Irrigate by furrows when possible.
Damping-off (*Pythium debaryanum*).	Young seedlings show water-soaked constriction of stem and lopping over of tops (fig. 36, *A*).	See page 45.
Scald	Rotting at base of plant near surface of ground.	Physiological. Avoid excessive watering.
	OKRA	
Wilt (*Fusarium vasinfectum*).	Stems become darkened near soil and plants eventually wilt completely, despite good soil moisture.	Do not rotate with solanaceous plants, such as eggplant, tomato, and potato, or with okra. Use seed from healthy plants. Sprays and dusts are of no value.
Leaf blight (*Cercospora* sp.).	Black spots develop on lower side of leaves. Eventually cover leaves, causing them to yellow and die.	Bordeaux mixture at weekly or 2-week intervals reduces damage, which appears mostly during wet weather.
Mold (*Aspergillus* sp.).	Black mold attacks flowers, causes rotting of young fruits.	Do.
	ONION, LEEK, GARLIC	
Soft rot (*Bacillus carotovorus*).	Bacteria attack bulb onions, causing a soft rot of bulb.	Harvest bulbs as soon as mature. Cure in a dry, well-aired place.

TABLE 11.—*Common vegetable diseases in the Tropics—symptoms and control* [1]—Continued

Disease	*Symptoms*	*Control*
Purple blotch (*Alternaria porri*).	Small white, large purple, or violet spots on leaves and flower stalks. Much destruction of plants results.	Colloidal copper dusts (cuprous oxide, copper lime, tri-basic copper sulfate, or copper oxychloride).
Leaf anthracnose (*Colletotrichum chardonianum*).	Whitish spots on leaves.	Do.
	PIGEONPEA	
Stem canker	Cankers at base of trunk, causing eventual wilting and death of plants.	
Leaf spot (*Cercospora vignae*).	Small brownish-yellow spots on leaves. Not very important.	
	YAUTÍA	
Leaf spot	Dark yellow irregular spots on leaves. Damage usually insignificant.	Remove and destroy diseased leaves.
Wilt	Yellowing of leaves, dwarfing and eventually death of plants.	Destroy diseased plants immediately. Use clean seed for new plantings.

[1] Local agricultural institutions should be consulted on the control of diseases not listed in this table. Only a few of the minor diseases are listed here, as they are usually not serious when the major diseases are properly controlled.
[2] Tomato. [3] Pepper. [4] Eggplant. [5] Not in Puerto Rico.

Insect and Other Animal Pests

Under the year-round growing conditions of the Tropics injurious insects may invade the vegetable garden at almost any time. Whether they become destructive depends largely on the gardener's ability to combat them successfully at all times. To avoid damage, and perhaps loss of a crop, plantings must be inspected every few days from the time the seed is sown until the crop is harvested. In this way the presence of any threatening pests can be discovered before they have a chance to multiply and while there is still time to take adequate measures for their control.

INDIRECT CONTROL MEASURES

Insects can often be kept from becoming injurious by adopting the general practice of sanitation and clean culture about the garden. Destruction of all trash and weeds or other plants that serve as breeding places a month or two before the land is prepared will destroy many insects that might later infest the garden. These sources of infestation should be eliminated from as large an area as practicable around the garden, as well as from the garden area itself. This includes the destruction of the remnants of a crop by plowing under or burning as soon as the fruit or other part is harvested. For example, uprooting cabbage or broccoli stalks after the heads are cut will remove a breeding place for the diamondback moth.

Plants kept in good growing condition through planting at the right season, adequate fertilization, and timely watering can resist the attack

of many pests. Certain varieties of vegetables mentioned in this circular are known to be less susceptible than others to insect injury. The planting of these resistant varieties can materially reduce the loss from insect attack and sometimes the need for expensive control. Frequent rotation—that is, planting a different kind of vegetable in the place of the one just harvested—helps prevent the build-up of certain pests on a particular crop.

The natural enemies of insect pests should be protected as much as possible. Birds, toads, lizards, and ladybeetles, all of which consume large numbers of injurious insects, are among the familiar friends of the vegetable grower. Internal parasites attract less attention but are no less beneficial. They can be protected by not destroying obviously parasitized forms, such as larvae bearing white cottony cocoons on yuca or cassava leaves and other plants. All these indirect practices, especially if supplementing more direct measures, will help to reduce the loss from injurious insects and frequently account for the difference between a good crop and a poor one.

DIRECT CONTROL MEASURES

Direct measures of control include the use of mechanical means and the application of poisonous chemicals, or insecticides, on the plant parts upon which the insects feed, or on the insects themselves.

Some insects, especially if noted early when they occur in small numbers, can sometimes be effectively brought under control by simply picking them off the infested plants or crushing them by hand. This means of control can be practiced at any time and at little cost when only a few plants are involved. Plowing to expose them to birds and other predators helps to destroy many soil-infesting insects. Burning with weed-torches or other means is effective against armyworms, webworms, and grasshoppers when they occur in large numbers. Mechanical protectors placed about the plants are often very effective. A good example is heavy paper or the leaves of the mamey tree (*Mammea americana* L.) wrapped around the stem of new transplants to ward off the attack of such insects as cutworms and mole crickets at or below the surface of the ground (fig. 43).

Other insects, particularly those that occur in too large numbers or in places too inaccessible to be controlled by mechanical means, must be controlled by insecticides. The kind of insecticide to use depends on the type of insect to be controlled. Insect pests may be grouped into two main types, based on their habits of feeding: Chewing insects, such as many beetles and caterpillars; and sucking or rasping insects, such as bugs, aphids, scale insects, thrips, and spider mites.

Chewing insects obtain their food by biting off pieces of the leaves or other parts of plants and are susceptible to poisons swallowed with their food. Insecticides that kill in this manner, such as arsenate of lead, are called stomach poisons, and to be effective they must be applied where they will be eaten by the insects.

Sucking or rasping insects obtain their food by piercing the plant with a tubular beak or proboscis, or by rasping the surface with their mandibles, and sucking out the plant sap. Insects of this type are unaffected by the so-called stomach poisons. To kill them, an insecticide has to act directly on the insect's body, either by contact or as a gas or vapor.

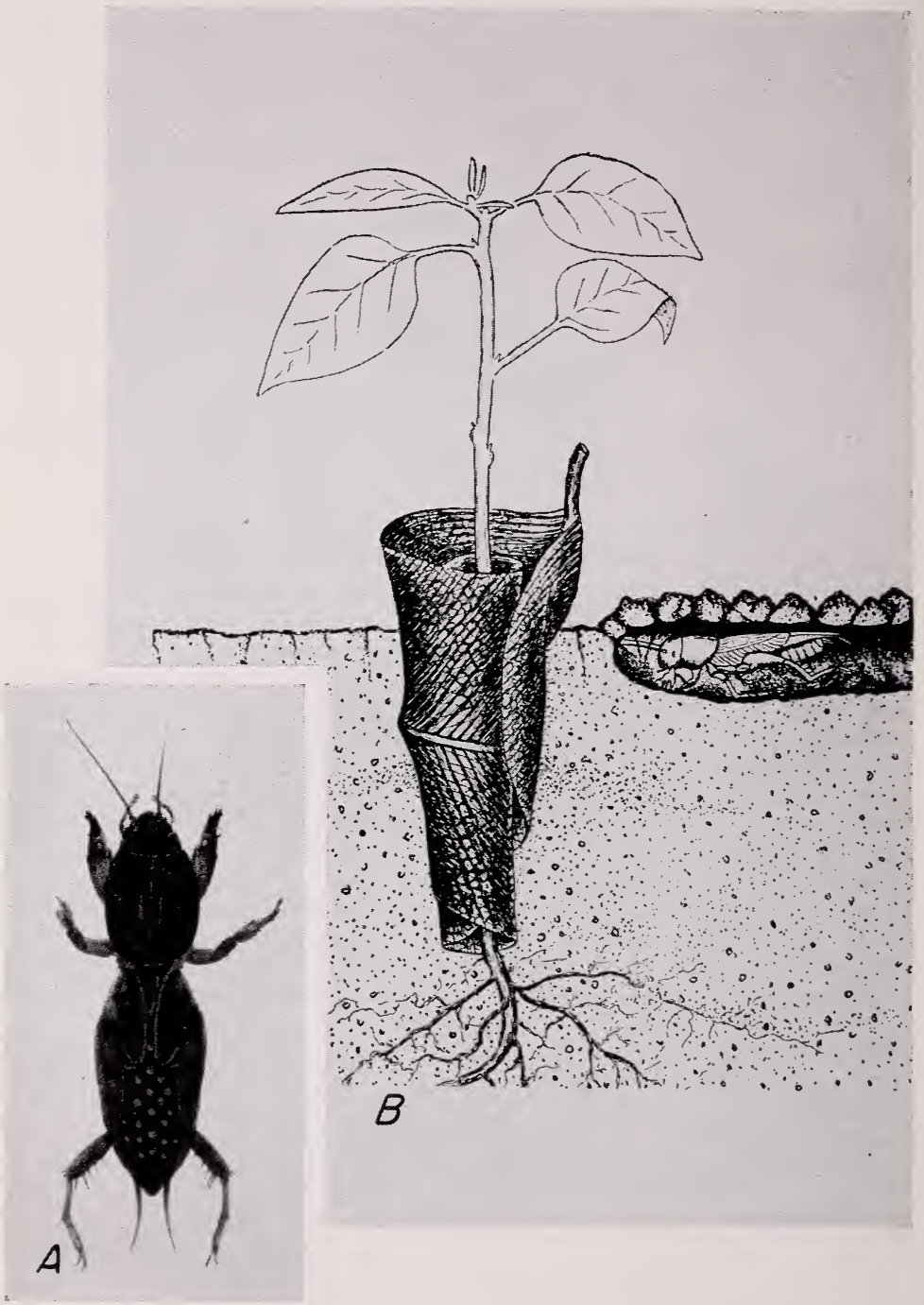


FIGURE 43.—The common West Indian mole cricket or "changa" (*Scapteriscus vicinus* (Scudd.)), a serious pest in sandy soil:
A, Nearly full-grown nymph (enlarged 1.5 times).
B, Method of protecting transplants by wrapping mamey leaf around trunk; note characteristic surface burrow at right being made by nymph or adult (*43, p. 3*).

Insecticides that kill mostly by contact, such as nicotine and DDT, are known as contact insecticides. Those, such as carbon disulfide, that generate a poisonous gas or vapor, are known as fumigants. Obviously, to be effective, contact insecticides must be directed to where the insects tend to congregate, usually the under side of leaves, so that the poison will come in contact with one part or another of the body of the sucking or rasping insect. Under certain conditions the fumigants may be used for either type of insect.

Stomach Poisons

There are several standard stomach poisons which every vegetable grower should have on hand. Those most commonly used are the arsenates of lead and calcium, available on the market as dry powders in various sizes and kinds of packages from 1-pound canisters to 100-pound drums. They can be procured from local drug stores, seed houses, or farmers' supply stores. Paris green, also a common stomach poison, is available in packages as small as ¼ pound. Other stomach poisons having special uses in the vegetable garden are cryolite (sodium aluminum fluoride) and the fluosilicates of barium and sodium.

Because of their highly poisonous nature, the foregoing materials should be used with caution. All of them leave a poisonous residue that is difficult to remove by ordinary washing, and even small amounts, especially of arsenate of lead, are hazardous to human health. Unless special care is taken to remove them from edible portions by wiping or washing, or both, their use should be confined to the plant part that will not be eaten or to plants in their early stages of growth.

Derris, cubé, or timbo dusts, or liquid extracts containing rotenone made from these materials, are often preferred on vegetables because at the strengths recommended they do not leave residues harmful to man or other warm-blooded animals. They are especially desirable on leafy crops or others near harvest. A dry form is available on the market in packages of various size, from 1-pound cartons to 100-pound drums. The extracts are available in containers holding from 2 fluid ounces to a gallon or more.

Lead Arsenate.—As a spray this arsenical is usually applied at the rate of 3 to 5 pounds in 100 gallons (2½ to 4 level tablespoonfuls per gallon) of water or bordeaux mixture, depending on the resistance of the insect to be controlled. It can also be combined with sulfur, nicotine sulfate, and oil sprays. For use as a dust it is mixed with about 5 times its weight of hydrated (air-slaked) lime. For the small gardener a convenient method of mixing is to place the ingredients in a tight can or small barrel with a few pebbles from 1 to 1½ inches in diameter. The container is shaken or rotated in all directions for several minutes to mix the materials thoroughly. The pebbles can be removed easily by emptying the contents onto a coarse screen.

Calcium Arsenate.—This material usually contains 70 percent of active ingredient and for this reason is somewhat less effective, pound for pound, than lead arsenate. The remaining ingredient is lime. Like lead arsenate, it can be used as a spray or dust, but in either form it tends to burn foliage more than the lead compound. However, it leaves a less

poisonous residue and is useful against certain insects on potato, tomato, and eggplant and on broccoli, brussels sprouts, cabbage, and cauliflower in the seedling stage.

As a spray, calcium arsenate is usually applied at the rate of 5 pounds per 100 gallons (4 tablespoonfuls per gallon) of water or bordeaux. If water alone is used, delicate plants may be slightly injured. To prevent this it is well to add strained milk of lime, prepared by slaking 2 pounds of freshly burned lime in about 4 gallons of the water, or by adding double this amount of dry finely screened hydrated lime (2 level tablespoonfuls per gallon) directly to the solution. As a dust, calcium arsenate may be used as it comes from the package or diluted with 2 or 3 parts by weight of hydrated lime and mixed as described for lead arsenate dust.

Paris Green.—As this material may cause more burning of foliage than either calcium or lead arsenates, its use is ordinarily confined to baits (p. 125). In some localities, however, it may be more readily available than the other arsenicals. When a quick-acting poison is needed on the more resistant crops, such as potatoes, and on tomatoes and eggplants *when not in fruit*, paris green can be used as a spray at the rate of 3 pounds per 100 gallons (2 level teaspoonfuls per gallon) of water, with 6 pounds of hydrated lime per 100 gallons (3 level tablespoonfuls per gallon). For dust mixtures 1 pound of paris green is thoroughly mixed with 10 pounds of hydrated lime.

Cryolite.—Both the natural and the synthetic forms of cryolite, as they leave a somewhat less dangerous residue, are replacing the arsenicals for use on vegetables. However, they usually lack the adhesiveness of the arsenicals and so must be applied more frequently or used with a sticker. The synthetic form is preferable to the natural, ground material because of its superior physical properties. It does not generally injure foliage and for this reason is particularly useful in the control of pod borers and other chewing insects on beans and closely related plants. It can be used in combination with nicotine sulfate, sulfur, and oil sprays. As a spray it is generally applied at the rate of about 5 pounds to 100 gallons (8 level teaspoonfuls per gallon) of water. As a dust, 1 part is mixed with 1 to 4 parts by weight of flour, sulfur, tobacco dust, talc, or clay. Mixtures containing cryolite, either as sprays or dusts, should never be used with lime or bordeaux. Severe burning of the plant may result from such use.

Barium Fluosilicate.—This powdered stomach poison has much the same properties as cryolite and is used at the same strength and in the same combinations.

Sodium Fluosilicate.—Because of its greater solubility, sodium fluosilicate is not so safe to use on foliage as the two foregoing fluorine compounds. For direct application on plants, it is used principally as a dust mixed with about 5 times its weight of flour, talc, or clay, but never with lime or bordeaux mixture. It can also be used as a substitute for paris green in poison baits.

Rotenone.—The dry, powdered roots of derris, cubé, and timbo as ordinarily available contain about 5 percent of rotenone and in addition varying proportions of other rotenone-like compounds, which also have insecticidal value. These dusts and the commercial extracts made from them are very toxic to some insects. They act as stomach poisons against many of the small leaf-chewing types common in gardens and

by contact against soft-bodied sucking insects, such as aphids. Rotenone sprays are not nearly so lasting in action as the foregoing stomach poisons, but they do not injure plants and are safe to use shortly before harvest on such crops as bean, melon, cucumber, and maturing cabbage, celery, and cauliflower. Killing action is somewhat slower than that of most contact insecticides.

Rotenone is usually applied as a dust at 0.75 percent strength at the rate of 20 to 30 pounds per acre. This is equivalent to about 3 ounces per 100 feet of row. Such a dust can be bought already prepared for use or it can be mixed at home. In the latter case, 4 pounds of powdered root containing 5 percent of rotenone is combined with 21 pounds of carrier, such as dry fine-ground gypsum, sulfur, talc, clay, or tobacco dust. If the powdered root available contains less than 5 percent of rotenone, a proportionately larger amount will have to be used. Lime, copper-lime dust, or bordeaux are never used as carriers for rotenone compounds. For application on melon and cucumber, other carriers than sulfur are used.

Rotenone can also be applied as a spray, using ½ ounce (3 level tablespoonfuls) of dry ground root containing 5 percent of rotenone to 1 gallon of water, or 3 pounds to 100 gallons. The powder is first thoroughly mixed with a small quantity of water and then added to the rest of the water in the sprayer. Commercial extracts contain 2 to 3 percent of rotenone with other active ingredients. For the dilution of these extracts the manufacturer's directions on the package should be followed.

In some parts of the Tropics the freshly dug roots of derris, cubé, and timbo, or barbasco, may be more readily available to the vegetable grower than the commercially prepared powders or extracts. These fresh roots are easily crushed and soaked in water overnight and the liquids strained through a cloth to give a milky infusion which can be used as a spray in place of the commercial products. About 1 pound of fresh root thus extracted in 5 gallons of water should make a spray closely approximating that described in the first part of the preceding paragraph (*30, p. 446*). This spray has to be used immediately as it spoils on standing.

Contact Insecticides

Rotenone compounds, nicotine, pyrethrum, DDT, sulfur, and whale oil or other soaps are the contact insecticides most commonly used on vegetables. One of the new synthetics, benzene hexachloride (BHC or "gammexane") has been recommended as superior to any of these for certain garden pests (*15, pp. 63–64*). Other more recently developed insecticides, such as chlordane, chlorinated terpenes, and parathion, are on the market, but their use is still too much in the experimental stage to warrant their recommendation for use on vegetables at this time.

Although chiefly effective against sucking insects, the first four contact poisons mentioned above can be used successfully in place of the arsenicals to control the early stages of many chewing insects on vegetables and thus avoid poisonous residues at harvesttime. Nicotine, or tobacco, and pyrethrum are available in both dry and liquid or extract forms and in almost any size container, from that suitable for the home gardener to that used by the large market grower. A number of forms of DDT and benzene hexachloride are on the market in both small and large packages. All these materials, with sulfur and whale-oil soap, are

often sold by local drug stores or farmers' supply houses, or they may be procured from seed supply firms or directly from the manufacturers. If kept dry, and the nicotine and pyrethrum materials well sealed, all, except perhaps benzene hexachloride, can be stored almost indefinitely without loss of potency.

NICOTINE.—Although ground tobacco dusts are useful against aphids and other small sucking insects, the commercial extract nicotine-sulfate containing 40 percent of the alkaloid is the most convenient form for the average gardener. From it dusts, as well as liquid sprays, can be prepared. Most soft-bodied sucking insects are controlled with the dilution of 1 part to 800 parts of water (1 pint to 100 gallons or 1 teaspoonful to 1 gallon), but for large sucking insects or if low-pressure sprayers are used, the strength should be doubled. This spray may be combined with arsenicals for the control of both sucking and chewing insects. The addition of 1 cubic-inch cake of mild laundry soap (2 level tablespoonfuls of flakes) per gallon or 4 to 6 pounds per 100 gallons depending on the hardness of the water, will increase wetting power and killing action. Soap is omitted when nicotine is combined with bordeaux.

To prepare small quantities of nicotine dust, 1 ounce (5 teaspoonfuls) of 40-percent nicotine sulfate is lightly sprinkled over 1 pound of finely sifted hydrated lime and thoroughly mixed as described for arsenate of lead. This nicotine dust either has to be used as soon as made or stored in a tightly closed container, as it quickly loses strength because of the volatilizing action of the lime on the nicotine.

Nicotine sulfate, especially the undiluted 40-percent material, is very poisonous. Care should be taken, therefore, to keep it from getting on the skin, in the eyes, or about the mouth.

PYRETHRUM.—Like nicotine, pyrethrum is available in the dry form, but the liquid extract is more convenient and less wasteful for most small gardeners. It comes combined with nicotine or rotenone in various proportions. There are a number of extracts of pyrethrum on the market, but some contain kerosene for use against household insects and will severely injure plants. Therefore, the gardener should be sure that the extract he intends to use on garden plants is manufactured for that purpose and can be mixed with water. Such an extract usually contains 2.4 grams of active ingredients (pyrethrins) per 100 milliliters. Under conditions in Puerto Rico an extract of this strength greatly increases the effectiveness of white mineral oil, at the proportion of 1 to 5 by volume, in the control of worms and maggots in the tips of sweet corn ears (*4, pp. 15, 21*). In general, pyrethrum is much quicker in action than rotenone but does not last so long. The insect must be hit by the spray, and there is no lasting action on the surface of the plant like that obtained from applications of rotenone and the arsenicals. The manufacturer's directions on the package should be followed, whether the liquid or dry form of pyrethrum is used.

DDT.—This new synthetic organic insecticidal material, chemically known as dichloro-diphenyl-trichloroethane, has recently shown itself effective in the control of a wide range of vegetable insects, as well as of household and animal pests. Its action is mostly by contact and the residue it leaves is so toxic to so many different kinds of insects that it is now largely replacing some of the older insecticides. When applied as ordinarily recommended, it seems to disappear quickly from the plant

and thus to create little or no residue problem. Under light-rainfall conditions at sea level in Puerto Rico, beans sprayed with DDT have shown no trace of this compound after 10 days (*35, 1947*). It is possible that under similar conditions elsewhere in the Tropics this material will behave in like manner.

However, from our present knowledge DDT must be considered as a poison and, therefore, should not be used on any parts of plants that are to be eaten unless the poison residues can and will be removed by washing, stripping, or other methods.

Although much investigational work remains to be done before the place of DDT in the control of vegetable insects can be established, it is now known that it can be used against insects without immediate injury to most vegetable crops except squash, cucumber, melon, and some varieties of lima beans, and sometimes tomato and related plants. It is particularly effective against leafhoppers and thrips, but not against most species of aphids. It is not effective against red spiders or mites, and its use may result in the increase of these pests on some garden plants unless sulfur or other material toxic to mites is applied at the same time. DDT can be combined with all the ordinary insecticides and fungicides used in the garden, except those containing large amounts of lime.

Of the various forms on the market, the agricultural grades made for use on plants and containing 25 and 50 percent of DDT in a wettable powder are the most convenient for the average gardener. For many insects, like leafhoppers and thrips, these powders are applied at the rate of 1 pound of *actual* DDT per 100 gallons of water or other liquid spray. This is equivalent to 2 pounds of the 50-percent material per 100 gallons, or 1 ounce (4 tablespoonfuls) in 3 gallons. For the 25-percent matrial, or for insects difficult to control, these quantities are doubled.

For dusting, the 3-percent strength is commonly used. This can be bought ready prepared or it can be made by thoroughly mixing 1 pound of the 50-percent material with 15½ pounds of talc or clay. In application, the whole plant, including both sides of the leaves, is thoroughly wetted or dusted often enough to keep the new growth well covered, so that the largest number of insects will come in contact with the residue.

As DDT and its decomposition products appear to last a long time in the soil and are toxic to some plants in some soils, care should be taken to avoid using excessive or unnecessary amounts. There is a possibility that a harmful amount will accumulate in the soil under some conditions, but it is not yet known how long it might take for harmful effects to develop.

Benzene Hexachloride.—Benenze hexachloride is another new synthetic organic material that has recently come into prominence as an insecticide. Prepared commercial powders containing 50 percent of benzene hexachloride or 5 percent of the gamma isomer are available for use as sprays or dusts.

Experimental work with benzene hexachloride is still too limited to indicate its usefulness in the control of insects on vegetables. However, from what has been done it appears that it would be somewhat more effective than DDT and the arsenicals against grasshoppers, white grubs, and possibly a few other insects that might be pests in gardens. Effective control of grasshoppers has been obtained with a bait containing as

little as 0.01 pound of the gamma isomer (equivalent to about 3 ounces or about 11 tablespoonfuls of the 50-percent commercial powder) to 24 pounds of bran. Against white grubs, ⅓ to 1½ pounds of gamma isomer (approximately 10 to 30 pounds of the commercial 50-percent powder) per acre has given good results, depending on the type of soil. Treatment can be made with a dust or a spray, the material being immediately mixed with the soil by cross disking or by hand to a depth of from 6 to 9 inches (*29, p. 227*). Benzene hexachloride should not be applied to soils in which root or tuber crops are to be grown, because of the possibility of its giving an undesirable flavor or odor to the products harvested from such soil. Its persistence in the soil may also lead to a toxic residue problem.

Like DDT, benzene hexachloride injures cucurbits and, therefore, should not be used on or near cucumber, melon, and squash plants. It is considered to be somewhat more toxic to human beings than DDT, temporarily irritates the skin and nasal passages, and has the added disadvantage of tainting some fruits, as well as root crops, with its persistent and disagreeable musty odor. In view of these preliminary results, it would seem well, for the present at least, to be cautious in the use of benzene hexachloride on vegetables, and until more information is available, restrict its application to crops other than the leafy vegetables and plants in fruit.

As with DDT, this material must be considered as a poison and handled with the same precautions. The law in some places prohibits the use of benzene hexachloride on all food products and on feed which will be consumed by milk or beef cattle.

Sulfur.—Sulfur is particularly active against red spiders or mites, sometimes called spider mites, and also controls some insects. The two forms most useful to the vegetable gardener are the wettable powder and the finely ground dust. Both forms are much superior to ordinary flowers of sulfur or sulfur flour and can be combined with the arsenicals and DDT. Wettable sulfur is usually employed at the rate of 4 pounds per 100 gallons of spray (2½ level tablespoonfuls per gallon). The dust can be applied undiluted or mixed 9 parts with 1 part of lime, or with this amount of arsenate of lead to make the dust suitable for controlling mites and chewing insects at the same time. Where mites become a problem in the control of bean insects with DDT, good results have been secured in Puerto Rico by adding wettable sulfur to the DDT spray at the above strength. Sprays and dusts containing sulfur severely burn cucumbers and melons and should not be used on these crops.

Soap.—Whale-oil and fish-oil soaps have been used for a long time to control small soft-bodied insects, such as aphids, but against more resistant insects they have little value except to aid the spreading (*17*) and, therefore, the killing power of other insecticides. For use as insecticides, most of these soaps, which may be more or less liquid, are usually employed at about 2 ounces to 1 gallon of water, or at double this amount if the water is hard.

Mild laundry soap is nearly as effective and always readily available. This is used at the rate of about 4 cubic-inch pieces of cake soap, or 8 level tablespoonfuls of flake or powdered soap, per gallon of water. Both are dissolved in half the quantity of hot water, the cake soap first being

cut into small shavings, and then the total volume is brought up to the full amount. On tender plants, such as young cabbage, garden peas, and beans, they should be used at half strength.

Fumigants

Sometimes a fumigant will be needed to control weevils and other storage insects in harvested dry beans and various seeds. Fumigants most useful to the average gardener are carbon disulfide, naphthalene or moth balls, and paradichlorobenzene. Most drug or hardware stores carry one or more of these materials.

Carbon Disulfide.—This is one of the oldest and about the best of fumigants for general use on thoroughly dry seeds and food products. At proper dosage it does not affect germination or leave a bad taste.

Carbon disulfide is very inflammable and its fumes are highly explosive. Great care should be taken to see that all flames and sparks are kept at a distance so long as an odor of the gas is perceptible.

For ordinary purposes from 10 to 20 pounds (about 1 to 2 gallons of 25 percent carbon tetrachloride and 75 percent carbon disulfide) are used for each 1,000 cubic feet of space, depending on how tight the enclosure can be sealed. The equivalent for small lots would be from 1 to 2 teaspoonfuls of the mixture for each gallon of space. The completely dry seed is placed in an air-tight container of known capacity and the required amount of carbon disulfide is poured into a dish or on paper or cloth placed *on top* of the seed. Keep the container tightly closed for 24 hours. The treated seed should be thoroughly ventilated in open air to avoid possible injury to germination, and then stored in a sealed container to prevent reinfestation.

Naphthalene.—Naphthalene is sometimes mixed with seed to kill infesting insects or to prevent reinfestation. It may be procured as flakes or in the familiar form of moth balls. To kill insects it has to be used in large amounts in a tight container for a much longer period of time than carbon disulfide, and such treatment may reduce the germinating power of some kinds of seed. For this reason it is usually employed as a deterrent to prevent infestation. About a tablespoonful of the flakes or two naphthalene balls to the quart of seed should be sufficient.

Paradichlorobenzene.—This white crystalline compound with a pleasant naphthalene-like odor is used mostly as a general household fumigant and sometimes to kill insects in seed. One ounce or 2½ level tablespoonfuls of the crystals is used to each 125 cubic feet of space. Use an airtight container as with carbon disulfide but allow about 3 days for the crystals to volatilize. Unless used at high concentrations and for long periods this treatment is considered harmless to seed that is to be planted. However, to reduce probability of such damage any crystals remaining after 3 days should be removed and the seed aired for a while to remove the fumes before transferring to a closed container (*15,p. 62*).

Surplus treated seed should be destroyed unless it can be stored where there is no possibility of its being used for food or animal feed.

Spreaders and Stickers

Spreaders are added to sprays to reduce the surface tension of the liquid sufficiently to make it wet the surface of the plant or insect to which it is applied. They are particularly desirable in the spraying of smooth or waxy-leaved plants, like cabbage, that are difficult to wet. Spreaders not only make sprays go farther, i.e., cover more surface per gallon and thus decrease the cost of an application, but they also greatly improve control. They cause suspended materials, such as arsenate of lead and cryolite, to form a uniform deposit over the plant and thus make it more likely that the insect will get a fatal dose than when the spray dries in a blotchy uneven coating of poison. Spreaders also increase the killing power of contact poisons, such as nicotine sulfate, by causing these poisons to wet the body of the insects quickly and thoroughly. Thus, by using spreaders it is often possible to reduce both the strength and the quantity of both kinds of insecticides that may be needed to produce adequate control. In using spreaders, care should be taken to add only enough to the spray solution to wet the plant or insects easily and when these are once wet not to apply more spray. Otherwise, the spray solution will be wasted and suspended materials will tend to flow off the plant with the excess liquid.

Stickers are materials that increase the adhesive or sticking qualities of an insecticide, that is, hold it on the plant long enough for the insects to eat it or come in contact with it. They are particularly useful when it is desired to keep suspended materials from being washed off by rains or overhead irrigation, such as on cabbage (before heading), tomato eggplant and bean (before the fruits are formed), and potato. Stickers may thus reduce the number of applications necessary to control certain insects. However, stickers should be used cautiously for they make difficult the removal of spray deposits by ordinary as well as natural means. Therefore, they should be used only in sprays applied during early stages of growth or on those parts of plants that will not be eaten, and never on leafy green vegetables.

There are a number of good proprietary spreaders and stickers on the market in both liquid and dry form that are convenient to use. One or more of these may be procured at farmers' supply houses. However, some of the oldest, and perhaps the best for ordinary purposes, may be more readily available to most vegetable growers in the Tropics. For example, soaps are excellent spreaders, and compatible with many garden insecticides. Some of the yellow laundry soaps also contain rosin, which enhances their value as stickers as well as spreaders. Other materials useful as spreaders or stickers or both are flour, casein or skim milk with lime, cactus juice, bentonite, and linseed oil.

Flour.—Either wheat flour or soybean flour at the rate of ½ to 4 pounds per 100 gallons of water makes a good sticker. They are sifted slowly into the spray tank while the solution is being agitated. Since these flours have poor wetting qualities, their performance is improved by the addition of a spreader containing sodium lauryl sulfate, such as "Dreft" or some of the other soapless wetting or washing compounds (*28, p. 130*).

Casein with Lime.—This acts as a sticker as well as a spreader. The commercially prepared powder, marketed under the name of calcium caseinate, is a mixture of 1 part of casein powder and 3 parts of hydrated

lime, and should be used according to the directions on the package (*28, p. 130*). If not obtainable locally, sufficient calcium caseinate for 15 gallons of spray can be made by mixing together 3 ounces of casein and 7 ounces of hydrated lime with sufficient water to form a smooth paste (*11, p. 8*). One gallon of skimmed milk can be substituted for the casein in the above formula.

Cactus Juice.—In some arid regions the mucilaginous juice of the prickly pear cactus may be used as both a spreader and sticker for all the arsenicals except arsenate of lead alone. It also can be used for bordeaux mixture alone or in combination with the arsenicals including arsenate of lead. In southern Texas from ⅓ to 1 pound of cactus, depending on how near the water the plants have grown, is used to every gallon of water employed in the spray mixture (*16, pp. 17–18*). In Jamaica 1 pound to 25 gallons of spray is recommended (*11, p. 7*). The padlike upper parts of the plant are thinly sliced, preferably at right angles to the spines, and soaked in water from 12 to 24 hours. The liquid is passed through a fine screen before using to remove particles that might clog the spray nozzle. If the infusion is not used immediately, a preservative should be added to the strained solution to prevent fermentation. Copper sulfate at the rate of about 1 pound, or salicylic acid at ⅙ pound, for each 50 pounds of cactus extracted is good for this purpose (*16, pp. 13–14*).

Bentonite.—Bentonite is a colloidal clay that is sometimes used as a diluent for dusts to make them stick to foliage, and also as a spreader and sticker for sprays on plants with foliage hard to wet, such as cabbage and onion. Most kinds of bentonite combine with nicotine to form nicotine bentonite in which most of the nicotine is insoluble in water and acts as a stomach poison instead of a fumigant or contact insecticide. The amount of bentonite to use varies with the insecticide and the kind of bentonite, and, therefore, the directions on the package should be carefully followed (*19, p. 6*).

Linseed Oil.—For arsenate of lead alone or bordeaux mixture alone, or the two combined, one of the best stickers is ordinary raw linseed oil. The quantity to use is 4 ounces of oil for each pound of arsenate of lead or other insoluble material (including copper sulfate as well as lime) in the spray mixture, regardless of the amount of water (*17, p. 26*). The oil is poured slowly into the tank after the spray materials have been thoroughly mixed with water and while the mixture is being agitated. For best results, good and continuous agitation should be provided while the spray is being applied.

Since mixtures containing linseed oil adhere strongly to all parts of the plant to which applied, their use should be confined solely to those parts that will not be eaten by man or fed to livestock.

Preparation of Sprays and Dusts

Sprays and dusts should be prepared as accurately as possible. This is especially true in making up small amounts. Inexpensive spring or "family" scales weighing by ¼ pound up to 20 pounds can be purchased in most hardware stores or from mail order houses, as can measuring spoons and cups and larger fractional measures of a gallon. The tables included here will be found helpful in preparing varying quantities of insecticides for application.

LIQUID MEASURE.—The usual United States units and their abbreviations are given in the following tabulation. Metric units are given in parentheses.

3 teaspoonfuls (t.)	= 1 Tablespoonful (T.) (15 milliliters (ml.))
2 Tablespoonfuls (T.)	= 1 fluid ounce (fl. oz.) (30 milliliters)
8 fluid ounces	= 1 cup (C.) (237 milliliters)
2 cups	= 1 pint (pt.) (473 milliliters)
2 pints	= 1 quart (qt.) (946 milliliters)
4 quarts	= 1 gallon (gal.) (3.8 liters (l.))

WEIGHT.—The avoirdupois ounce (oz.) is equivalent to approximately 28.3 grams (gm.). Sixteen ounces equal 1 pound (lb.), or approximately 454 grams.

MEASUREMENT BY BULK.—The measurement of dry material by bulk, or volume, is more convenient, although not quite so accurate, when only small quantities are prepared. Any slight over-dosage resulting from this method is usually compensated for by inefficiency of equipment used in applying such quantities. It is not advisable, therefore, to employ this method in preparing more than 5 gallons of spray or 3 pounds of dust, for the application of which larger and more efficient equipment is used.

The following tabulation shows the approximate number of level tablespoonfuls (T.) of dry material needed to weigh 1 ounce:

Materials:	*Level tablespoonfuls (T.) per ounce*
Arsenate of lead	4½
Arsenate of calcium	5
Paris green	1½
Cryolite	2⅔
Barium fluosilicate	4
Sodium fluosilicate	2
Derris or cubé root powder (5-percent rotenone content)	6
Hydrated lime	3
Wettable sulfur	4
Paradichlorobenzene	2½
Wheat flour	4½
Soybean flour	6⅓
Corn meal	3⅔
Metaldehyde (meta)	7
BHC, 50 percent, wettable powder (5-percent gamma isomer content)	3⅔[1]
DDT, 50 percent, wettable powder	4[1]

[1] Since the carriers or diluent powders used in these materials vary a great deal in bulk, the gardener should determine the bulk of his particular brand by actual weight and measurement before using this method.

MAKING DILUTIONS.—Most control recommendations designate the strength of the spray solution to be used as so many parts by volume or weight per 50 or more gallons of water or other liquid, such as "1–50," "3–50," or "6–100," "1–800," etc. This terminology may also be used by manufacturers on the labels of packaged insecticides. Unless otherwise stated, it means that so many parts by liquid measure (of liquid) or by weight (of dry material) are used to make up the designated number of gallons of spray. For example, the recommendation, "nicotine sulfate 1–800," means that 1 gallon of the commercial nicotine sulfate containing 40 percent of active ingredients is to be diluted with water or other liquid up to the total volume of 800 gallons of spray, or a proportionately smaller amount for a smaller quantity of spray. Likewise, the recommendation, "arsenate of lead 3–50," means that 3 pounds of this

dry material are used to make up 50 gallons of spray, the same proportion or rate being used whether larger or smaller quantities of spray are prepared.

The proportionate amounts of liquid material needed to make up commonly used quantities of spray are given in table 12 for most of the usual dilutions. Amounts needed for other quantities and other dilutions can be conveniently calculated from these figures. Similar information for dry material is given in table 13.

TABLE 12.—*Amount of liquid material to make sprays of certain dilutions*

Dilution	Volume[1] of liquid material to make—			
	50 gallons	5 gallons	3 gallons	1 gallon
1–50	1 gallon	26 T.	1 C.	16 t.
1–100	½ gallon	13 T.	8 T.	8 t.
1–200	1 quart	7 T.	4 T.	4 t.
1–400	1 pint	3 T.	2 T.	2 t.
1–600	⅔ pint	2 T.	4 t.	1⅓ t.
1–800	1 C.	5 t.	3 t.	1 t.
1–1,000	13 T.	4 t.	2¼ t.	¾ t.

[1] All measures are United States standard containers: gal. = gallon, qt. = quart, pt. = pint, C. = measuring cup, T. = Tablespoonful, t. = teaspoonful.

TABLE 13.—*Amount of dry material to make sprays of certain dilutions*

Dilution	Weight of dry material to make—			
	50 gallons	5 gallons [1]	3 gallons [1]	1 gallon [1]
	Pounds	*Ounces*	*Ounces*	*Ounces*
1–100	0.5	0.8	0.48	0.16
2–100	1.0	1.6	.96	.32
3–100	1.5	2.4	1.44	.48
4–100	2.0	3.2	1.92	.64
5–100	2.5	4.0	2.40	.80
6–100	3.0	4.8	2.88	.96
8–100	4.0	6.4	3.84	1.28

[1] Amounts for 1 to 3 gallons of spray can usually be measured more conveniently by bulk. Multiply amounts here given by bulk shown in tabulation on page 120.

To insure a uniform spray mixture, liquid material is first diluted gradually by stirring in small amounts of water up to a total of about twice the original volume. Dry material is similarly made into a smooth thin paste. Materials thus broken up are added directly, or preferably through a sieve, to the half-filled spray tank, and thoroughly stirred while the tank is being filled to make the total quantity of spray needed. Thorough agitation should be provided during application to prevent the settling of suspended materials, such as arsenate of lead and DDT.

Quantity of Sprays and Dusts to Apply

Only enough spray or dust should be applied at one time to obtain complete coverage of the plant or insects treated. The quantity neces-

sary for a given area depends on the accessibility of the parts or insects to be covered, the size of plants, their spacing, and the amount of breeze. Assuming little or no drift on account of wind, the following information can be used as a basis for estimating the quantity of materials needed.

Sprays.—From 1 to 2 quarts of liquid spray is usually required per 50 feet of row for each application on plants of medium size, such as bush beans. With the rows spaced about 2½ feet apart, this is equivalent to about 150 to 200 gallons per acre.

Dusts.—From 1 to 1½ ounces of dust mixture are ordinarily sufficient for one thorough application on 50 feet of row of medium-size plants. Depending on the row spacing and the bulk of the dust carrier, this equals about 20 to 30 pounds per acre.

GENERAL FEEDERS

In every tropical vegetable garden there are a number of pests, such as aphids, cutworms, snails, etc., that attack many different kinds of plants without much discrimination. These general feeders may be controlled by the following methods:

Ants.—Various kinds of ants often cause direct damage by attacking seed, small plants in seedbeds, or even large plants. Others cause indirect injury by disseminating and fostering infestations of other insects, such as aphids and mealybugs, from which they obtain excreted honeydew for food. Infestations of the fostered insects often subside when the ants are controlled.

An emulsion of crude carbolic acid, soap, and water sprayed on the plant or sprayed or poured into the nests is very effective against the fire ant (*Solenopsis geminata* (F.)) and should control without injury to the plant, most other ant species troublesome in vegetable gardens. A stock solution is made by stirring 1 quart of black, crude carbolic acid into 1 quart of hot water in which ½ pound of laundry soap (cake, flakes, or powdered) has previously been dissolved. When well mixed, sufficient water is added to bring the total volume to 2 quarts. For use, ½ pint or 1 measuring cup, of this stock solution is diluted with 3 gallons of water (*53, p. 31*).

DDT is effective against this ant and a number of others. Plants sprayed with DDT in wettable powder at 1–100 were practically free of ants for several weeks (*35, 1947*). One to several teaspoonfuls of the dry material introduced into the nests, depending on size, has eliminated them entirely.

To prevent the direct damage to seed planted in flats or boxes, some growers elevate them on short stakes. As additional protection these stakes can be painted with the crude carbolic acid emulsion undiluted or with a thin paste made with wettable DDT powder and water. If elevation of the flats is impracticable, the DDT powder can be dusted every 2 weeks on the ground around them, or between the rows of newly planted seed and around the edges of the seedbed.

If leaf-cutting ants are nesting in the vicinity of the garden, it would be well to eliminate all colonies before starting to plant. These ants are mostly pests of citrus and other trees, but also may do considerable damage to vegetables. They remove pieces of the leaves and take them into their nests for growing a fungus. This fungus, not the leaves, is the food of the colony. Hence poisoning the leaves is of no effect and

control can be obtained only by fumigation. A safe and effective fumigant for this purpose is paradichlorobenzene. From 1 to several ounces of the crystals are poured into each of the major entrances to the nest, depending on size, after which all entrances are closed by tamping with moist soil.

Carbon disulfide also is effective against leaf-cutting ants. To prevent the liquid from being absorbed by the ground around the entrances, it is introduced into the nest through a funnel having a spout 10 to 12 inches long. One fluid ounce of 25 percent carbon tetrachloride and 75 percent carbon disulfide should be sufficient for small nests with only one or two holes, while up to 20 fluid ounces of the mixture may be necessary for large to very large nests covering an area 3 or more yards in diameter. The total amount of carbon disulfide estimated for the nest is divided among several of the largest entrances according to size, and all the other entrances or exits are tightly closed with soil. To distribute the fumigant to all the chambers in large nests, it has been found advantageous to explode the gas a few minutes after treatment. This can be done safely by holding to each entrance a small torch on the end of the long pole. However, all the entrances and other holes opened by the explosion must be quickly closed, or most of the gas will burn off and the effect of the treatment will be greatly reduced (*32*). One application of either paradichlorobenzene or carbon disulfide should be sufficient to kill all the inhabitants of the colony, but the nest should be inspected frequently for several weeks and treatment repeated through any new openings that may occur.

Because of its highly explosive nature, carbon disulfide requires careful handling.

Aphids or Plant Lice.—These are small, plump, soft-bodied insects up to about ⅛ inch long and of various colors from pale yellow to deep olive green or almost black. They congregate on the underside of leaves and about the tender growing tips of many plants (fig. 31). They pierce the surface of the plant tissue with their tubular mouth parts and suck out the plant juices, causing the leaves to curl, turn brown, and drop. The tips of the plant also wither. Under dry weather conditions aphids are apt to be very injurious on some plants, particularly cucumber, eggplant, pepper, and potato, if not controlled as soon as noticed and before the leaves curl. Spray with nicotine sulfate 1–800 plus whale oil or other soap 2–100, or rotenone-pyrethrum concentrate according to the manufacturer's directions; or apply nicotine-lime, rotenone, or pyrethrum dusts. If bordeaux mixture is used, reduce the nicotine sulfate to 1–1,000 and use a soapless spreader. Use only nicotine or pyrethrum on leafy vegetables intended to be eaten as greens, such as mustard and lettuce.

Crickets.—Mole crickets make characteristic tunnels just under the surface of the ground (fig. 43). They feed on the roots and lower stem of many kinds of plants and are particularly damaging in loose sandy soil. When a few acres are to be used for the vegetable garden, the mole cricket population can be reduced by broadcasting a poisonous bait immediately after plowing and harrowing. This bait is made by thoroughly mixing 8 pounds of sodium fluosilicate with 100 pounds of wheat bran or half wheat bran and cottonseed meal, and adding enough water to make a crumbly mixture (*59, pp. 4–5*). It is thinly and evenly scattered over the surface of the ground at the rate of 20 pounds per acre,

and about 5 days or a week are allowed for the crickets to be poisoned before planting is begun. A radius of several yards around this area is also treated at the same time. The dampened bait should be used immediately, as it will soon spoil. If only small quantities are needed, it is best to use proportionately smaller amounts than here given, or only moisten that quantity of the dry mixture which will be sufficient for present needs.

For small areas it is better to place the poisoned bait in narrow trenches 1 inch deep about 3 inches around individual plants, between rows, or along the edges of beds. When the infestation is light, individual plants can be protected with cardboard or similar barriers wrapped around the stem at transplanting, as suggested for cutworms. The use of leaves from the mamey tree (*Mammea americana* L.) for this purpose (fig. 43) has been effectively practiced against the Puerto Rican mole cricket. Besides acting as a barrier, mamey leaves also have some insecticidal value (*33, p. 738*).

Impregnating the infested soil with DDT also has given good results. A suspension made by mixing 1 pound of the 50-percent, wettable powder with 5 gallons of water is applied with a sprinkling can at the rate of 1 gallon per 100 square feet (*5, p. 663*).

Other crickets, that hide during the day under trash or in cracks in the soil, may be sufficiently numerous to cause severe damage. These can usually be controlled by removing their hiding places and by using the foregoing bait or that recommended for cutworms.

Cutworms and Armyworms.—These are thick, smooth to nearly hairless caterpillars measuring up to 2 inches in length. They are brown to gray-brown in color and inconspicuously marked with shades of yellow, gray, and black. These colors enable the larvae to blend with the color of the soil in which many of them hide during the day. They feed mostly at night. Some, like typical cutworms, cut off plants at or near the surface of the ground; others, like typical armyworms, strip off the leaves of grasses and other plants, or burrow into the fruit (fig. 44).

Internal parasites and predatory birds and other animals keep these pests so reduced in numbers that those remaining can be controlled by other means. However, under some conditions these caterpillars may become so numerous as to be exceedingly destructive. When they consume all the plants in one place, they begin to march in a mass in search of others, hence the name armyworm. When this migration occurs, a trench can be plowed across and ahead of their path with the flat side or wall facing the line of advance. The marching larvae will collect at the bottom of this trench, where they can be killed by dragging a log or roller over them, or by spraying them with kerosene.

About the most satisfactory method of controlling these insects under all conditions is the application of a bait composed of wheat bran or other carrier poisoned with one of several stomach poisons, as in the following formula:

Components:	Quantities	
	Large	*Small*
Dry wheat bran	25 pounds	1 lb.
Paris green, calcium arsenate, or sodium fluosilicate	1 pound	2 T.
Molasses	1 quart	2 T.
Water, enough to moisten slightly, or about	2 quarts	12 T.

FIGURE 44.—Typical cutworm injury to bean plant. (Slightly reduced.) Cutworms of various species hide in soil or under objects on surface and come out at night and cause damage to many vegetables.

Wheat bran is preferred on account of its attractiveness, but if not obtainable, commercially prepared, branlike cattle feed, corn meal, rice meal, or low-grade flour may be substituted. Thoroughly mix the bran and the poison; then slowly add the molasses diluted with a little water, and remix. Only enough water should be used to make the particles cling together when squeezed in the hand. If paris green is employed, bait distribution is restricted to bare soil or vegetation of no economic value, as this poison will cause severe leaf burning. The bait can be spread in a thin ring 3 inches around the base of small plants or along rows to protect from cutworms hiding in the soil. If the bait is made from one of the other poisons, it can be scattered lightly over both the soil and large plants. Over large areas it is broadcast at the rate of 20 to 30 pounds per acre. Application is made in the late afternoon so that the bait will remain moist and attractive for the maximum time. This treatment is repeated several times at 4- to 10-day intervals until damage becomes negligible.

The storage of highly poisonous bait is unsafe; such baits should be mixed only as needed and all surplus should be destroyed.

To protect a small number of newly set plants, use stiff paper or a mamey leaf, as described for mole crickets, or set the plant through a hole made in the bottom of a 3- or 4-inch paper drinking cup.

GRASSHOPPERS.—Both adult and wingless young grasshoppers may be very destructive to vegetables, particularly where rainfall is light. Natural enemies, such as birds and lizards, usually keep grasshoppers from reaching destructive numbers. However, when they become epidemic, the poisoned bait suggested for cutworms and armyworms (page 124), should give effective control. Benzene hexachloride (BHC) used as mentioned under Contact Insecticides (p. 115), also is effective.

LEAFHOPPERS.—Leafhoppers are slim, wedge-shaped, jumping and flying insects about ⅛ to ¼ inch long that suck the sap from the underside of leaves and tender shoots of many plants causing the leaves to curl and turn brown. They are of various colors, the most injurious ones on potatoes and beans being light green (fig. 45). Sometimes leafhoppers occur in such numbers as to fly up in clouds when the leaves are disturbed. Death of the plant follows heavy infestation, but more frequently production decreases or the plant dies from one or several virus diseases that these insects frequently transmit.

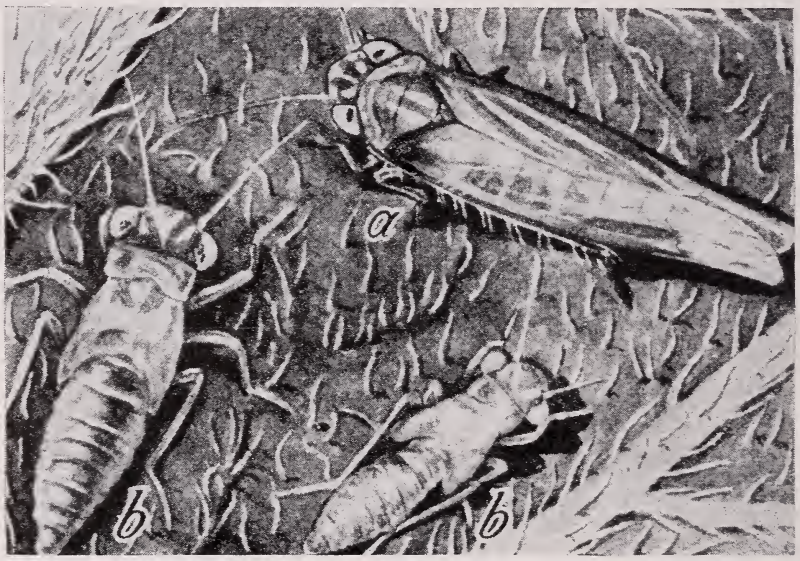


FIGURE 45.—Potato leafhopper (*Empoasca fabae* (Harr.)) in different stages of development on underside of leaf: *a*, Adult leafhopper; *b*, nymphs (or young leafhoppers). (*a* and *b*, about 17 times natural size.) (*54*). This and similar species are serious pests of beans in some parts of the Tropics.

Infestations on some crops, such as potatoes, may be held in check by the standard spraying with bordeaux mixture for fungus diseases. If aphids are present, the addition of nicotine sulfate, as recommended on page 123 will tend further to reduce the leafhopper population. If chewing insects are also active, arsenate of lead 2–100 may be combined with this spray on all plants but legumes. On legumes, spray the under side of the leaves every 3 or 4 weeks with DDT 1–100.

MILLIPEDES.—These cylindrical, brownish to red, slow-moving, worm-like animals measuring up to several inches in length are common in piles of fresh stable manure and vegetable matter. The body is composed of many hard segments, each of which bears two pairs of legs. During the rainy season millipedes may become so numerous, particularly in damp soils high in organic matter, that they attack living plants.

Damage to plants in seed flats can be prevented by thoroughly sifting the soil before planting and elevating the flats on racks. Since millipedes do not usually inhabit well-rotted manure or compost, only this kind of organic matter should be used on vegetables. If fresh manure only is available, it should be applied and worked into the soil well in advance of planting to allow sufficient time for thorough decomposition. Commercial fertilizers, particularly ammonium sulfate, tend to discourage the multiplication of millipedes. When needed, it would be well to make liberal applications of such fertilizer along with the manure. For local treatment, some relief can be secured by evenly distributing arsenate of lead either dry or in water over the ground at the rate of 1 pound for each 1,000 square feet and raking or spading it into the soil (*12, p. 81*).

RATS.—Rats sometimes cause more loss than insects by digging up seed or eating into fruits, such as corn ears, bean and pea pods, and tomatoes. Damage is apt to occur when piles of trash or heavy undergrowth are allowed to accumulate near the vegetable area. Such hiding places should be removed for a distance of 40 to 50 feet around the garden. If rats continue to be troublesome the gardener will have to resort to trapping or poisoning.

The guillotine or snap-type trap is satisfactory and easy to maintain. It should be baited with the kind of vegetable being attacked, or pieces of fresh dry coconut meat. Locate several of these traps 2 to 3 feet apart wherever damage has occurred. They should be placed in the runway, if one is evident, or in the path the rats will take to reach the feeding area.

For preventing damage in larger areas, as the digging up of field-planted seed, the use of poisoned bait has given good results. Phosphorus paste, spread on or mixed with the vegetable or seed being attacked, may be placed a foot or two apart in the area where rat damage is noticed. However, barium carbonate (obtainable at drug stores) is much less hazardous to other animals, cheaper, and better adapted to general use.

One part of precipitated barium carbonate is employed well mixed with every 6 parts of the favorite food (*45, p. 6*). At the Federal Experiment Station newly planted cornfields have been protected by the use of a bait mixture composed of 3 parts of corn meal, 2 parts of cracked corn, 1 part of grated coconut meat, and 1 part of barium carbonate (*35, 1943, p. 22*). All materials are mixed dry, then moistened with the milk from the coconut used. Water is added, if additional moisture is needed, to make the particles cling well together. Heaping-teaspoonful quantities are wrapped individually in oiled paper. These packets are distributed during the late afternoon at 5- to 6-foot intervals along the edges of the areas to be protected. Dipping the packets in soybean oil, corn oil, or raw linseed oil, greatly increases the attractiveness of the bait (*35, 1946, pp. 33–34; 10, pp. 163–167*).

SNAILS AND SLUGS.—These animals skeletonize, shred, or eat holes in leaves and fruits of many garden plants not regularly sprayed with bordeaux mixture or an insecticide. They hide during the day under leaves, trash, or stones, and come out at night to feed. Damage is heaviest during damp weather.

Although their numbers can be greatly reduced by hand-picking and injury minimized by destroying their hiding places, the best remedy for

snails and slugs is a poisoned bait containing metaldehyde. Many snail baits containing metaldehyde are available commercially, and these have given satisfactory results when used according to the directions on the package. A homemade bait can be prepared as follows (*12, p. 180*):

Dry wheat bran	1 pound
Blackstrap molasses	2 tablespoonfuls
Calcium arsenate	1 ounce
Metaldehyde, powder or pulverized pellets	½ ounce
Water	1 pint

The dry materials are first thoroughly mixed, after which the molasses diluted with water is stirred in. It is preferable to have the mixture a little wetter than is necessary to make the particles cling together when pressed in the hands. This bait should be applied during the evening by placing in "pinch-size" piles spaced about 4 to 6 inches apart. In rainy weather, loss of material can be avoided by placing tablespoonful quantities in small tin cans turned over on their sides.

Highly poisonous bait should not be stored, therefore it should be mixed only as needed and all surplus should be destroyed.

Metaldehyde, or "meta," comes in the form of powder or pellets. As pellets it is often sold as a substitute for fuel alcohol. The crude or unrefined, slightly crystalline material seems to be as effective as the refined white powder. However, if metaldehyde cannot be obtained, the bait is fairly satisfactory without it. Corn meal can be substituted for wheat bran in the foregoing formula. If ants molest this bait, the molasses can be omitted or about 1 teaspoonful of 50-percent DDT wettable powder added. The foregoing bait should be used immediately, or only that quantity moistened at one time which will take care of immediate needs.

Spider Mites.—These minute plant-infesting relatives of spiders are sometimes called "red spiders" because many of them are red in color. They have eight legs and an oval or round body which may be spotted. Infestation is mostly on the underside of leaves, where some mites spin light webs and so litter the leaves with eggs, molted skins, and excrement that the surface has a dull, dusty appearance. Their rasping-like feeding causes the surface to appear whitish or silvery and, in the case of leaves, finally to curl and turn yellow, then brown; in addition, fruits may become rusty, or otherwise scarred.

Spiders mites are not often very troublesome in the humid Tropics, but they may heavily damage some vegetables during the dry season and in localities where rainfall is light. A few lightly infested plants can often be freed of mites by syringing with a strong stream of water. For general use, however, spraying with wettable sulfur 4–100 or dusting with dusting sulfur will be found more convenient and usually more effective. The under side of the leaves should be thoroughly covered. Sulfur may be combined with other insecticides, if needed, and applied at the same time, as suggested under Contact Insecticides (p. 116). Isolated plants that become heavily infested with mites should be removed from the garden.

Dilute flour paste is effective as a spray against mites. It kills the mites by gluing them to the leaf. A stock solution is made by stirring 1 pound of wheat flour into 1 gallon of water and heating the mixture until it becomes sticky. This stock is sufficient to make 100 gallons of spray (*61, p. 272*).

White Grubs.—White grubs are the stout, wrinkled, brown-headed larvae of May beetles or "June bugs." They measure up to about 1 inch in length and are often found curled in a semicircle in the soil about the roots of many plants. White grubs trim off the small roots and sometimes chew into the lower part of the stem. The roots of tuberous plants, such as potato and sweetpotato, usually suffer the most damage. White grubs are apt to be most numerous in soil previously planted to grasses. Before the introduction of the Surinam toad (*Bufo marinus* F.) from Barbados by the Federal Experiment Station in 1920, white grubs were one of the worst pests of sugarcane in Puerto Rico. Chiefly because of the activity of this predator in feeding on the adult beetles, white grubs have been so reduced in numbers that damage to any crop is now rarely severe.

Injury by white grubs can be minimized by avoiding the use of grassland for vegetable gardens, frequent plowing to expose the larvae to birds and other predators, collection of the larvae from the soil about infested plants, and by the introduction and protection of natural enemies. Treatment of the soil with benzene hexachloride, as mentioned in the section on Contact Insecticides (p. 115), is also an effective control.

OTHER INSECTS LIKELY TO BE TROUBLESOME

Control measures are given in table 14 for insects of more restricted feeding habits than the foregoing but yet important in some parts of the Tropics. In using this table the gardener should bear in mind that conditions influencing insect infestation vary a great deal. On account of geographical location, altitude, and rainfall, and their known effects on both pest and crop, the pests of a given crop in one region may not be those that would damage the same crop in another region. Likewise, the relative importance of widely distributed pests and the measures needed to control them may differ widely from region to region. In case of doubt, therefore, the individual grower should consult local experienced gardeners and also discuss specific problems with the nearest agricultural officer or government research or extension institution.

Application Equipment for Pest Control

Thorough application in pest control is just as important as timeliness or the use of the right materials. Lack of thoroughness may be due to inadequate or faulty equipment. Pest control needs should be carefully considered in advance of planting the garden and equipment purchased that will most efficiently meet all requirements.

Whether to spray or dust is much the choice of the individual grower and also may depend somewhat on the conditions under which he works. For best results, he should be prepared to do whichever is the more efficient for a particular condition. When many plants are to be treated, spraying will usually be more satisfactory than dusting. Spraying is also the more economical operation and affords somewhat better opportunity for complete coverage with a smaller amount of material, even under slightly windy conditions. Sprays can be made to adhere better than dusts. On the other hand, dusting, although requiring more material for a given area, can be done quickly and, when there is no breeze, will ordinarily cover as completely as spraying. In localities with little rainfall dust applications will adhere and be effective for about as long

TABLE 14.—*Some important pests of vegetables in the Tropics and suggestions for their control*

Kind of insect and crops attacked	*Description and habits of insect. Remarks.*	*Suggested control*
BEETLES		
Flea beetles		
Beet Chard Eggplant Many legumes[1] Potato Sweetpotato Tomato	Black, dark-green, or brown-green, very active, jumping beetles up to 1/8 inch long eat small holes from surface of leaves, sometimes riddling them. Often very injurious to small plants. (Several species of flea beetles.)	Destroy all solanaceous[2] plants in vicinity of garden before planting. Keep leaves of suceptible plants covered with poisons by spraying with arsenate of lead 3–50 or cryolite 5–100 plus soapless spreader-sticker, or by dusting with equal parts of arsenate of lead or arsentate of calcium and hydrated lime, twice a week. On chard and beets used for greens spray or dust with nicotine; on legumes[1] use DDT or cryolite.
Beet Chard Ceylon spinach	Stout, bright-red, jumping beetle about 1/4 inch long with bright shining-green wings and its grayish larvae eat leaves of young plants. Sometimes extremely injurious in the West Indies.	Eliminate all wild plants related to beets, such as *Amaranthus* spp., from garden and vicinity. Protect very young plants with wire screens, recently established ones by spraying with arsenate of lead 3–50, older ones with rotenone or rotenone-pyrethrum.
Leaf beetles		
Asparagus	Green or black-and-yellow striped beetles about 1/3 inch long feed on flowers and leaves.	Arsenate of lead 3–50, or DDT 1–100; on cucumber family[3] use fluorine compounds or rotenone.
Cucumber family[3] Legumes[1] Sweetpotato	Bright red and black beetle about 3/16 inch long skeletonizes and eats holes in leaves (fig. 29,*B*).	Arsenate of calcium 2–50 with water or bordeaux, or cryolite 5–100 with sticker. (See Spreaders and Stickers, p. 118.)
BUGS		
Cabbage family[4] Cucumber family[3] Eggplant Tomato	Black, oval bugs about 3/8 inch long with orange or reddish markings; light green, shield-shaped bugs about 1/2 inch long having a foul odor; and brown-to-black bugs up to about 1/2 to 3/4 inch long with bright red or red and black young pierce the surface and suck juices from fruits, leaves, and tender parts of plants. Some cause distortion of fruits. (Several species of plant bugs.)	Hand pick large adults. Spray young with nicotine sulfate 1–600 plus soap 3–50. Keep fruit picked clean and all plants removed from garden as soon as they have finished bearing.
Eggplant Some legumes[1] Yautía	Sluggish light to dark-brown, flattish bugs about 1/8 inch long with lacy wings cause leaves to turn yellowish-white along midrib then to brown all over by sucking sap from under side. Cause great damage during dry weather if not controlled as soon as noticed. (Several species of lacebugs.)	Spray with nicotine sulfate 1–800 plus soap 3–50 or DDT 1–100, or use nicotine or pyrethrum dust. Destroy all solanaceous[2] plants in vicinity of garden, and promptly remove others from garden as soon as crop is finished.

See cautions, pages 31, 50, 98, and 111, 115, 117, on the use of chemicals.

CATERPILLARS		
Earworms and fruitworms		
Bean Eggplant Okra Pepper Pigeonpea Sweet corn Tomato	Thick, dull-brown to black and greenish-striped caterpillars up to about 1¾ inches long, that curl up when disturbed. They cut off young plants and burrow into tips of sweet corn plants and ears; also burrow into eggplant, pepper, and tomato fruits, and bean, okra, and pigeonpea pods. (Corn earworm or tomato fruitworm, fall armyworm, and tobacco budworm.) (Figs. 29,*D*, and 37.)	Control for cutworms will prevent cutting off young plants (see p. 124). Larvae in tip of sweet corn plants can be killed best by pinching the spindle or central whorl of leaves. For worms in sweet corn ears inject ¼ teaspoonful of white or medicinal mineral oil into base of silks with an oilcan or medicine dropper (½ average dropper full) as soon as silks have wilted (fig. 37,*B*); pyrethrum extract 1–5 or 2 percent of technical DDT added to the mineral oil will increase control (see p. 114). Harvest corn 2 months or more before planting to bean, eggplant, pepper, or tomato; on these crops spray or dust with arsenate of calcium or cryolite or scatter bait containing ½ pound cryolite and 5 pounds corn meal over plants and fruit clusters as soon as fruits set. On pigeonpea use arsenate of calcium or cryolite spray or dust.
Hornworms		
Cassava (yuca) Eggplant Pepper Sweetpotato Tomato	Dull, green or brownish caterpillars up to about 3 inches long, bearing horn-like process on rear end of body and sometimes diagonally striped on sides, voraciously feed on leaves and stems. (Cassava sphinx caterpillar, tobacco hornworm, and sweetpotato hornworm.) (Fig. 29,*A*.).	Hand pick. Usually heavily parasitized; do not destroy cottony masses made by parasites on leaves of cassava, papaya, and other plants. On sweetpotato, arsenate of lead 1–50 or stronger with sticker, as used for other insects, will give control if applied when caterpillars are small.
Leaf rollers, tiers, and webbers		
Beet Chard Many legumes[1] Spinach (all kinds) Sweetpotato	Slim, light yellowish-green to semitransparent-green larvae up to about ¾ inch long, begin feeding as tiny worms with webs on underside of leaves, gradually drawing and tying together more leaves (and pods on bean) as more food is needed and feeding on these from inside of web. (Bean leaf tier, Hawaiian and southern beet webworms, sweetpotato leaf roller.) (Figs. 25,*A* and 32,*A*.)	On greens spray or dust with pyrethrum or rotenone-pyrethrum. On legumes[1], if necessary, use arsenate of calcium 2–50 with bordeaux, or cryolite. On sweetpotato use arsenate of lead 1–50 plus sticker. Make applications to under side of leaves beginning as soon as insects are noticed and before leaves curl. For small number of plants larvae in webbed leaves may be crushed by hand. Elimination from garden and vicinity of *Amaranthus* spp. and all other weeds related to beets will reduce trouble from webworms.

TABLE 14.—*Some important pests of vegetables in the Tropics and suggestions for their control*—Continued

Kind of insect and crops attacked	*Description and habits of insect. Remarks.*	*Suggested control*
Cabbage family[4]	Finely striped, black-headed caterpillar up to ¾ inch long folds the leaves about growing tips and eats the hearts of the plants, causing serious damage, particularly to small seedlings. (Cabbage webworm.)	Spray or dust with arsenate of lead or calcium, rotenone or rotenone-pyrethrum on seedlings. Use only rotenone or rotenone-pyrethrum on bearing or heading plants or plants used for greens (*13,p.64*). DDT spray or dust should give good control if started early and directed into plant tips.
Cucumber family[3]	Whitish to greenish caterpillars up to about ¾ inch long with brownish head and with or without white stripes on back, web leaves together, attack buds and blossoms, and burrow into fruit. (Melonworm and pickleworm.) (Fig. 32,*B*.).	Before fruits form, apply aresenate of lead 3–50 with bordeaux, or arsenate of lead and hydrated lime 50–50 dust, paris green and lime 1–10 dust, or barium fluosilicate or cryolite dust to growing tips and blossoms weekly beginning as soon as young caterpillars are noted.
Loopers and other leafworms		
Beet Cabbage family[4] Celery Chard Lettuce Okra Potato	Velvety, green or striped caterpillars up to 1¼ inches long and looping caterpillars about 1 inch long eat holes in leaves. (See fig. 25,*B* for larvae of diamondback moth.)	On small plants use arsenate of lead, arsenate of calcium, cryolite, or barium fluosilicate sprays or dusts; after heads begin to form use rotenone or rotenone-pyrethrum sprays or dusts every week or 10 days. On lettuce use nicotine sulfate spray or dust. Add spreader to all sprays.
Pod borers		
Many legumes[1]	Creamy-white and black-spotted, and light-green, brown- or black-headed caterpillars about ⅔ inch long feed on blossoms and developing pods, causing them to drop, and bore into maturing pods, destroying their market value. Very serious on lima bean in West Indies. (Several species of bean pod borers.)	Spray with cryolite or dust with 80 parts of cryolite mixed with 20 parts of talc or dusting sulfur, (1) when small pods are forming and (2) when the pods are full grown but still green; on green or snap beans omit (2). Stimulate flowering by heavy fertilization. Small-podded lima beans are less damaged than the large-podded varieties.
Lima bean Pigeonpea	Velvet-green, slug-like caterpillars bore into pods.	Arsenate of calcium 3–100 or cryolite.
Stalk and vine borers		
Many legumes[1]	Slim, bluish-green caterpillar about 1 inch long bores into base of plants just below soil surface and spins silky tubular runway from entrance hole into loose soil. (Lesser cornstalk borer.)	Two to 3 inches of trash mulch about base of plants as soon as high enough might prevent infestation. Stimulate growth by heavy fertilization and watering.

Sweet corn	Dull white to cream-colored, black-spotted larva about ¾ inch long burrows in stalks, causing them to break off, and sometimes injures the ears. (Sugarcane moth borer.)	Plant as far as possible from sugarcane that is about to be harvested. Cut and feed or destroy stalks as soon as ears are harvested.
Sweetpotato	Pale yellowish or pinkish-white caterpillar up to about 1 inch long hatches on leaves and bores into stems and sometimes into tubers, leaving pile of excrement near crown of plants. (Sweetpotato vine borer.)	Spray or dust with cryolite 2 or 3 times at intervals of 3 or 4 weeks beginning 3 months after planting (*13,p.85*)
Yautía (dasheen or taro)	Smooth, black or dark-brown caterpillar about 1 inch long honeycombs corms and sometimes the lateral tubers. Makes brown cocoon about ¾ inch long in soil near corms. (Yautía corm borer.)	Destroy all caterpillars and cocoons found during harvest (*63, pp. 25–26*).
Tuberworm		
Eggplant Potato Tomato	White, yellow, pinkish or greenish caterpillar about ¾ inch long with dark-brown head mines leaves and burrows into eggplant and tomato fruits at stem end and into exposed surface of potato tubers in field and storage under dry conditions. (Potato tuberworm.)	Keep growing potato plants well hilled; harvest tubers early and sell or use promptly. Do not follow potato with eggplant and tomato; destroy all volunteer tomato plants.
Wooly caterpillars		
Bean Celery Many other vegetables	Black, wooly caterpillars about 2 inches long feed on bean pods and defoliate many other garden vegetables.	Hand pick, or spray with arsenate of calcium 3–100, cryolite, or DDT. Follow suggestions for Loopers and other leafworms.
MISCELLANEOUS		
Fruit and melon flies or maggots		
Cucumber Melon Pepper Squash Tomato	Small white maggots develop from eggs laid in fruit by yellowish flies and burrow around in flesh of fruits, causing them to decay. Very destructive in some Pacific and West Indian islands. (Melon fly and Mediterranean fruit fly.)	Cover fruit with cloth bags as soon as formed. Continually pick infested fruits and either burn or immerse them in water for 72 hours to kill maggots (*13,p.89, fig.62*). Remove all plants and fruits as soon as main crop is finished.
Sweet corn	Whitish maggots up to about ½ inch long feed on silks in end of husks and the end of cob and adjacent grains, causing silks, cob, and grains to turn brown and decay with foul odor. (Corn-silk fly.) (Fig. 23,*B*.)	Inject ear tips with mineral oil containing pyrethrum extract, as for ear and fruitworms. (See under Caterpillars.)
Leaf miners		
Eggplant Sweetpotato	Very small green or reddish caterpillars make round puckered mines in leaves, giving them a skeletonized appearance. Sometimes troublesome in eggplant seedbeds and a major pest of sweetpotatoes in some parts of the Tropics. (An eggplant leaf miner and sweetpotato leaf miner.)	Avoid overcrowding of seedbed; keep plants well watered. Spray with nicotine sulfate 1–400 at first indication of mining.

TABLE 14.—*Some important pests of vegetables in the Tropics and suggestions for their control*—Continued

Kind of insect and crops attacked	*Description and habits of insect. Remarks.*	*Suggested control*
Mealybugs		
Celery Eggplant Pepper Soybean Tomato	Olive green to pink or red, flattish, oval, slow-moving insects about 1/8 inch long, with white mealy or cottony covering and a white egg sack up to about 1/4 inch long, suck sap from leaves and stems. Some also attack the crown or roots, stunting or killing the plant, or increasing spread of virus diseases. Particularly troublesome on tomato in greenhouse gravel culture and on other plants where ants are common. (Mexican mealybug, and pineapple mealybug.) (Fig. 34.)	Spray with DDT 1–100 as soon as noted and every 2 weeks thereafter so long as necessary. This will eliminate attendant ants and kill crawling young as they hatch.
Scale insects		
Celery Eggplant Okra Pepper	Brown or black hemispherical scales about 1/8 inch in diameter and light greenish, elongate-oval flattish scales about 3/16 inch long suck plant juices from leaves, branches, and stems, causing them to die. (Several species of soft scales.)	Eliminate all solanaceous plants[2] from vicinity of garden. Spray with DDT as for mealybugs. Uproot affected crop plants as soon as they finish bearing.
Thrips		
Bean Eggplant Okra Pepper Pigeonpea Soybean Tomato	Slender inconspicuous insects about 1/16 inch long, straw-colored or black with brownish-gray bands across wings, and their slightly smaller yellowish-pink young, rasp the underside of leaves and inside of blossoms, giving them a whitish appearance and finally causing them to turn brown and drop. (Flower and bean thrips.)	Spray or dust with rotenone, rotenone-pyrethrum, or DDT every 2 or 3 weeks as may be necessary.
Cabbage Celery Lettuce Onion Potato Tomato	Slender greenish or yellowish brown adults about 1/16 inch long and their inconspicuous yellow-white young rasp the surface of leaves in tips or growing point and often the larger leaves, causing them to appear whitish or withered, then brown. Severely limits the production of bulb onions in many parts of the Tropics and also spreads some tomato diseases. (Onion thrips.) (Fig. 29,*C*.)	Same as above, except do not use DDT on heading cabbage and large celery or lettuce plants. On bulb onions spray with poisoned bait composed of 1 1/2 teaspoonfuls tartar emetic (available at drug stores) plus 5 teaspoonfuls brown sugar per gallon of water (*13,p. 73*). On commercial bulb or green onions dust with 5 percent of DDT plus 25 percent of dusting sulfur as soon as thrips number eight per plant and again 5 to 7 days later, using 25 to 35 pounds of dust per acre. Repeat these two applications when thrips again increase to eight per plant.[5] Plant resistant or early maturing varieties.

Weevils or snout beetles		
Bean Cowpea	Stout, dark grayish-brown or almost black weevils about ⅛ inch long bore round holes in dry beans. The small, white, grub-like larvae develop in the seeds from eggs laid in the young, green pods, and breeding continues in storage. (Bean weevils.)	To avoid taking the weevils to the field, fumigate seed before planting. Market or consume all dry beans as soon as possible after harvest, or fumigate and protect in air-tight containers. (See Fumigants p. 117).
Eggplant Pepper	Dark gray and reddish brown to black weevils about ⅛ inch long, some with curved snout, feed on leaves and lay eggs in flower buds, where the white legless grubs develop and cause the buds and small fruits to dry and drop off. Particularly injurious to eggplant in some parts of the West Indies. (Eggplant weevil and pepper weevil.)	Destroy all solanaceous plants[2] in vicinity of garden before planting. Spray with arsenate of lead or cryolite 5–100, or dust with rotenone-sulfur or cryolite-talc 50–50 containing 0.5 percent of rotenone every 5 to 7 days until injury ceases. Remove from garden and destroy all fallen buds and fruits.
Sweetpotato	Slim, blue-black, antlike weevil about ¼ inch long, having smooth reddish-yellow thorax and legs, and slightly smaller and stouter, dull-black, rough snout beetle with a broad yellow band across rear end of back feed on midrib and larger leaf veins and lay eggs in stems. The stout, whitish, legless grubs, about ⅜ inch long, burrow in stem down to tubers, which they riddle with tunnels. Tubers may also contain weevils. (Sweetpotato weevil and West Indian sweetpotato weevil—"Jacobs" or "Scarabee".)	Plant only weevil-free slips or tubers. Use new land far from old fields. Stimulate rapid growth. Harvest promptly as soon as mature, taking all tubers and vines from field and destroying all tubers found infested (*61, pp.646–653*). As soon as weevils are noted on leaves spray with arsentate of lead 2–50, or cryolite, with sticker two or three times at intervals of 3 or 4 weeks beginning about 3 months after planting (*13,p.85*).

[1] Bean, pea, cowpea, soybean, and related plants.
[2] Wild eggplant wild tomato, nightshade, and related plants.
[3] Cucumber, chayote, melon, pumpkin, squash, and closely related plants.
[4] Broccoli, brussels sprouts, cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, turnip, and related plants
[5] Hibbs, E. T. and Ewart, W. H. DDT for the control of onion thrips. Texas Agr. Expt. Sta. Progress Report 1042, 3 pp. October 17, 1946. (Mimeographed.) (See p. 2.)

FIGURE 46.—Types of garden spraying and dusting equipment:

A, Three-gallon compressed-air knapsack sprayer with brass funnel-top tank, trigger-type lock-open control valve, 18- and 22-inch brass extension rods, and angle nozzle for spraying under side of leaves; a convenient outfit for home gardens.

B, Five-gallon knapsack spray pump with brass tank and same equipment as shown in *A*; excellent for use on hilly land and terraces and for gardens up to several acres.

C, Rotary, single-spout hand duster with 14-inch extension tubes and equipment for treating two rows at a time; note lever (above circular fan box) for regulating dosage up to 20 pounds per acre; this knapsack duster is well adapted to small gardens or a limited acreage of vegetables.

D, Medium-size (13-inch) hand duster of the plunger type with extension pipes and deflector-flare nozzles for directing dust to under-side of leaves; convenient for "spot-dusting" or for treating a small number of plants at one time.

E, Eleven-gallon "estate" sprayer, gasoline-motor-driven wheelbarrow type, equipped with hose, 2-foot extension rod, and angle nozzles for spraying under side of leaves; suitable for either medium-size or commercial gardens up to several acres. Persons applying poisonous sprays should wear eye and respiratory protection. If the spray is caustic, hand, arm, and full face protection should be worn.

as sprays, especially if made while the plants are wet with dew or after sprinkling. Most dusting equipment is light and compact and, for this reason, easy to carry or operate in small areas and on hilly land or terraces. Both kinds of equipment are available in many sizes and capacities from small hand sprayers or dusters to large power machines.

For gardens of less than an acre, small to medium outfits are the most economical. The most satisfactory sprayer in this class would be one of the knapsack type. These are available in sizes from 2- to 5-gallon capacity. Some are operated with compressed air pumped in by hand (fig. 46, *A*); others are equipped with a hand-operated force pump having an air chamber (fig. 46, *B*). The best kinds of knapsack sprayers are made of brass or other noncorrosive metal and of such a design as to be conveniently carried on the back or shoulder of the operator and easily cleaned after use. They come equipped with hose, extension rods, and nozzles suitable for spraying the under side as well as the upper side of the leaves of both small and large plants. Knapsack sprayers are economical of man power, as only one man is needed to operate them.

Another sprayer which may also be satisfactory is a bucket pump that can be held with the foot and used by one man to spray small areas, or attached to a barrel for operation from a cart or pick-up truck by two men over larger areas (fig. 47). This pump, while costing less than the knapsack sprayer, is not so maneuverable, but some models have the advantage of being easily converted into an outfit of larger capacity whenever needed. When only a few plants have to be treated quickly, as in "spot-dusting," a medium-size dust gun will be found useful (fig. 46, *D*).

For areas of an acre or more planted with few varieties, a sprayer of larger capacity than the knapsack or bucket will often be required. The bucket pump described above can be adapted to a barrel and the barrel placed on a wheelbarrow or other vehicle. Any length of hose that is desired or necessary to spray from between rows can be attached. There are now on the market a number of portable, light-weight power outfits which are well adapted for use in market gardens or truck farms. These consist of a tank of wood or metal of from 10 to 50 gallons capacity mounted on two wheels of a size suitable for pulling over freshly prepared soil. The pump is driven by a small gasoline engine or electric motor and the capacity is sufficiently great to supply one or two ordinary nozzles at good pressure. The sprayers referred to are known as estate or greenhouse sprayers (fig. 46, *E*). While costing more than the barrel or large hand-operated outfits, they have the advantage that one man can operate them over a wide range of conditions. For greatest durability and the most efficient operation of all spraying equipment, the manufacturer's instructions accompanying it should be carefully followed. After use it should be thoroughly washed and stored under cover.

Large gardens should also have some dusting equipment available. One of the medium to large dust guns for "spot-dusting" would be desirable and perhaps also one of the large-capacity, rotary-type hand dusters for use on large areas. Dusters of the latter size come with extension tubes and nozzles for application of the dust to either one or two rows (fig. 46, *C*). The nozzles for both sizes, like those for dusters of smaller capacity, should be of the deflector type and capable of being turned in any direction so that the under side of the leaves can be adequately

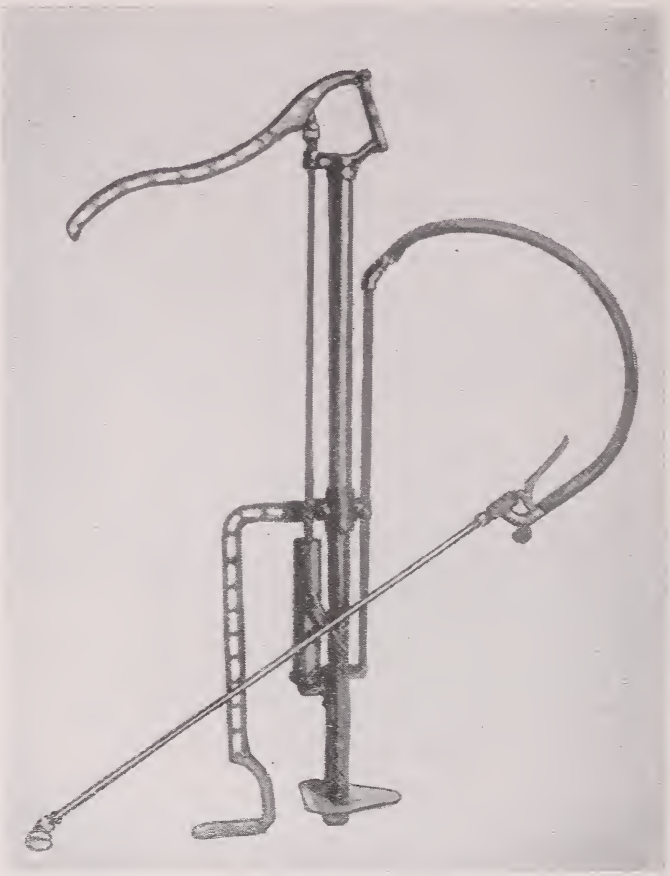


FIGURE 47.—Hand-spray pump of the bucket type with mechanical agitator; suitable for small gardens (*56, p. 29*). Some models have attachment at top for fastening to small barrel to increase capacity and range of adaptability.

covered (fig. 46, *C* and *D*). The best of the rotary-type dusters are equipped with a diaphragm for regulating the amount of dust entering the air stream and hence the amount applied in a given area. This is particularly desirable since frequent light, evenly distributed applications of dust are much more effective than a few heavy, poorly distributed ones. Dusting equipment, like that for spraying, gives longest and most efficient service if kept carefully cleaned and stored in a dry place when not in use.

Where Fungicides and Insecticides May Be Purchased

Indications have been given at various places in the text as to where most of the materials useful for the control of diseases and insects affecting vegetables may be purchased. Such materials and the equipment for applying them can usually be obtained from seed houses and dealers in agricultural supplies or machinery in many tropical regions. The common kinds are often stocked by drug and hardware stores in small towns. If these supplies cannot be obtained locally or in adequate quality or quantity, the grower should consult his nearest agricultural research or extension institution.

LITERATURE CITED

(1) Anonymous.
1946. nutriculutre. U. S. War Dept. Tech. Manual TM-20-500, 84 pp., illus. Washington 25, D. C.
(2) ———
1947. rhubarb protects teeth. Sci. News Letter 52(16): 252.
(3) ———
1948. tomatoes in puerto rico. Market Growers Jour. 77(5): 25, 39, 40, 42. 51.
(4) Bailey, W. K.
1940. experiments in controlling corn ear pests in puerto rico. Puerto Rico (Mayagüez) Fed. Expt. Sta. Cir. 23, 23 pp., illus.
(5) Bruce, W. G.
1946. ddt to control puerto rican mole crickets. Jour. Econ. Ent. 39: 662-663.
(6) Childers, N. F., and Seguinot Robles, P.
1947. slcbolt lettuce for the tropics. Agr. in Americas 7: 93–95, illus.
(7) Cook, M. T.
1939. enfermedades de las plantas económicas de las antillas. Puerto Rico Univ., Monog. Phys. and Biol. Sci., Ser. B, No. 4, 530 pp., illus.
(8) Del Valle, C. G.
1943. el maíz dulce. Cuba Fstac. Expt. Agron. Bol. 62, 18 pp., illus.
(9) Doolittle, S P.
1943. tomato diseases. U. S. Dept. Agr. Farmers' Bul. 1934, 83 pp., illus.
(10) Doty, R. E.
1945. rat control on hawaiian sugar cane plantations. Hawaii Sugar Planters' Sta., Agr. and Chem. Bul. 55: 71–239, illus. [*Also in* Hawaiian Sugar Planters' Rec. 49(2): 71–239, illus. 1945.]
(11) Edwards, W. H.
1936. insecticides to control insect pests in jamaica. Jamaica Dept. Sci. and Agr. Bul. 6 (n.s.), 50 pp., illus.
(12) Essig, E. O., and Hoskins, W. M.
1944. insects and other pests attacking agricultural crops. Calif. Agr. Col. Ext. Cir. 87 (rev.), 197 pp., illus.
(13) Frazier, W. A.
1943. home gardening in hawaii. Hawaii Agr. Expt. Sta. Bul. 91, 115 pp., illus.
(14) Hendricksen, H. C.
1906. vegetable growing in porto rico. Puerto Rico (Mayagüez) Expt. Sta. Bul. 7, 58 pp., illus.
(15) Herklots, G. A. C.
1947. vegetable cultivation in hong kong. 208 pp., illus. Hong Kong.
(16) High, M. M.
1915. cactus solution as an adhesive in arsenical sprays for insects. U. S. Dept. Agr. Bul. 160, 20 pp.
(17) Hood, C. E.
1929. fish oil as an adhesive in lead arsenate sprays. U. S. Dept. Agr. Tech. Bul. 111, 28 pp., illus.
(18) Hopkins, E. F., Pagán, V., and Ramírez Silva, F. J.
1944. iron and manganese in relation to plant growth and its importance in puerto rico. Puerto Rico Univ. Jour. Agr. 28: 43–101, illus.
(19) Howard, N. F., Weigel, C. A., Smith, C. M., and Stemer, L. F.
1943. insecticides and equipment for controlling insects on fruits and vegetables. U. S. Dept. Agr. Misc. Pub. 526, 56 pp., illus.
(20) Kikuta, K., Hendric, J. W., and Frazier, W. A.
1945. pearl harbor—a tomato variety resistant to spotted wilt in hawaii. Hawaii Agr. Expt. Sta. Cir. 24, 4 pp., illus.
(21) Kinman, C. F., and McClelland, T. B.
1916. experiments on the supposed deterioration of varieties of vegetables in porto rico, with suggestions for seed preservation. Puerto Rico (Mayagüez) Agr. Expt. Sta. Bul. 20, 30 pp., illus.
(22) Kiplinger, D. C., and Laurie, A.
1942. growing ornamental greenhouse crops in gravel culture. Ohio Agr. Expt. Sta. Bul. 534, 52 pp., illus.

(23) KRAUSS, F. G.
1932. THE PIGEON PEA (CAJANUS INDICUS) ITS IMPROVEMENT, CULTURE AND UTILIZATION IN HAWAII. Hawaii Agr. Expt. Sta. Bul. 64, 46 pp., illus.
(24) KRONE, P. R., and others.
1945. THE HOME VEGETABLE GARDEN. Mich. Col. Ext. Bul. 4 (rev.), 96 pp., illus.
(25) LANGHAM, D. G.
1942. MAÍZ DULCE, VENEZUELA-2, UNA NUEVA CLASE DE MAÍZ. Venezuela Inst. Expt. de Agr. y Zootec. Cir. 3, 4 pp.
(26) MACMILLAN, H. F.
1935. TROPICAL PLANTING AND GARDENING. Ed. 4. 560 pp., illus. London.
(27) MCCLELLAND, T. B.
1928. STUDIES OF THE PHOTOPERIODISM OF SOME ECONOMIC PLANTS. Jour. Agr. Res. 37: 603–628, illus.
(28) MCCLINTOCK, J. A., and FISHER, W. B.
1945. SPRAY CHEMICALS AND APPLICATION EQUIPMENT. 320 pp., illus. La-Grange, Ind.
(29) MAXWELL, K. E.
1947. BENZENE HEXACHLORIDE—INSECTICIDE. Chemurg. Digest 6(14): 224–228, illus.
(30) MERINO, G., and OTANES, F. Q.
1937. CONTROL OF INSECTS AND OTHER PESTS. Philippine Jour. Agr. 8: 437–461, illus. (Farmers' Cir. 20, rev.)
(31) MORALES OTERO, P.
1946. PUERTO RICO'S NUTRITIONAL PROBLEM. Pan Amer. Union, Bol. Ofic. Sanit. 25(3): 229–240.
(32) PLANK, H. K.
1921. LA HORMIGA ARRIERA Y LOS MEDIOS PARA COMBATIRLA EN LAS HUERTAS DE CACAO DEL ECUADOR. Ecuador Asoc. de Agr. del Bol. (Rev. Agr.) 1(3): [37–45].
(33) ———
1944. INSECTICIDAL PROPERTIES OF MAMEY AND OTHER PLANTS IN PUERTO RICO. Jour. Econ. Ent. 37: 737–739.
(34) ———
1946. THE CONTROL OF STORAGE INSECTS IN CORN SEED. Jour. Econ. Ent. 39: 314–319, illus.
(35) PUERTO RICO (MAYAGÜEZ) AGRICULTURAL EXPERIMENT STATION.
1903–1948. [VEGETABLE CULTURE.] Puerto Rico (Mayagüez) Fed. Expt. Sta. Ann. Rpts. 1903, p. 424; 1904, p. 403; 1905, pp. 32–33; 1907, pp. 21–22; 1909, p. 23; 1910, p. 29; 1912, p. 27; 1914, p. 26; 1915, pp. 27–28; 1919, pp. 20–21, 25–26; 1920, pp. 19–23; 1922, pp. 1–2; 1923, p. 3; 1925, pp. 38–39; 1926, pp. 8–9; 1928, pp. 9–12; 1929, pp. 16–19; 1930, pp. 16–17; 1931, pp. 9–18; 1932, pp. 7–16; 1933, p. 17; 1934, pp. 17–19; 1935, pp. 13–16; 1936, pp. 39–61; 1937, pp. 37–67; 1938, pp. 59–77; 1939, pp. 45–62; 1940, pp. 50–51; 1941, pp. 13–14; 1942, pp. 10–11; 1943, pp. 19–20; 1945, pp. 31–33; 1946, pp. 23–26, 33–34; 1947, pp. 30–39; 1948, pp. 10–14.
1907–1925. [DISEASES.] 1907, pp. 35–36; 1917, p. 28; 1925, pp. 30–40.
1902–1947. [INSECT PESTS.] 1902, p. 342; 1907, pp. 35–36; 1947, pp. 16–18, 58–60.
(36) PUERTO RICO (RÍO PIEDRAS) AGRICULTURAL EXPERIMENT STATION.
1915–1948. [ANNUAL REPORTS]
(37) REED, W. W.
1941. THE CLIMATE OF THE WORLD. U. S. Dept. Agr. Yearbook 1941: 665–684, illus.
(38) RIOLLANO, A.
1943. THE EFFECTS OF STAKING AND PRUNING ON TOMATO PLANTS. Puerto Rico Univ. Jour. Agr. 27: 17–26.
(39) ———
1943. A NEW VARIETY OF MUSKMELON FOR PUERTO RICO. Amer. Soc. Hort. Sci. Proc. 42: 574.
(40) ———
1943. LOUISIANA RED CREOLE, A NEW PROMISING ONION VARIETY FOR PUERTO RICO. Amer. Soc. Hort. Sci. Proc. 43: 272–274, illus.

(41) Roberts, R. C., and others.
1942. soil survey of puerto rico. U. S. Bur. Plant Indus., Soil Surv. Rpts., ser. 1936, No. 8, 503 pp., illus.
(42) Rohwer, C.
1943. design and operation of small irrigation pumping plants. U. S. Dept. Agr. Cir. 678, 78 pp., illus.
(43) Seín, Jr., F.
1942. los insectos dañinos en las hortalizas. Agr. Expt. [Puerto Rico Univ. Sta.], 2(2): 2–5, illus.
(44) Serrano, L. A., Esteva, Jr., C., and Riollano, A.
1936. hortalizas para la exportación en la zona de regadío de isabela, aguadilla, y moca. Puerto Rico (Río Piedras) Agr. Expt. Sta. Cir. 105, 56 pp., illus.
(45) Silver, J.
1933. rat control. U. S. Dept. Agr. Farmers' Bul. 1533, 21 pp., illus.
(46) Skinner, J. J.
1941. plant-nutrient deficiencies in vegetable or truck-crop plants. *In* Hambidge, J. C., ed., Hunger Signs in Crops: A Symposium. pp. 149–189, illus. Washington, D. C. (Amer. Soc. Agron. and Natl. Fert. Assoc.)
(47) Somers, I. I., and Shive, J. W.
1942. the iron-manganese relation in plant metabolism. Plant Physiol. 17: 582–602, illus.
(48) Staebner, F. E.
1940. supplemental irrigation. U. S. Dept. Agr. Farmers' Bul. 1846, 73 pp., illus.
(49) Stuart, N. W.
1948. growing plants without soil. Sci. Mo. 66(4): 273–282, illus.
(50) Tecson, A. L.
1938. a preliminary survey of the watermelon industry in bulacán and pampanga. Philippine Jour. Agr. 9(4): 365–380, illus.
(51) Thompson, H. C.
1939. vegetable crops. Ed. 3, 578 pp., illus. New York.
(52) Thompson, J. B.
1926. gardening in the virgin islands. Virgin Islands Agr. Expt. Sta. Bul. 6, 19 pp., illus.
(53) Tower, W. V.
1911. insects injurious to citrus fruits and methods for combating them. Puerto Rico (Mayagüez) Fed. Expt. Sta. Bul. 10, 35 pp., illus.
(54) United States Department of Agriculture.
1941. potato leafhopper. U. S. Dept. Agr., Bur. Ent. and Plant Quar. Picture Sheet No. 8, 2 pp., illus.
(55) Virgin Islands Agricultural Experiment Station.
1921–1932. [annual reports.]
(56) White, W. H., and Doolittle, S. P.
1944. a victory gardener's handbook on insects and diseases. U. S. Dept. Agr. Misc. Pub. 525, 30 pp., illus.
(57) Whittaker, C. W., Brown, B. E., and Adams, J. R.
1948. ammonium nitrate for crop production. U. S. Dept. Agr. Cir. 771, 28 pp., illus.
(58) Wilson, C. E.
1923. truck-crop insect pests in the virgin islands and methods of combating them. Virgin Islands Agr. Expt. Sta. Bul. 4, 35 pp., illus.
(59) Wisecup, C. B., and Hayslip, N. C.
1943. control of mole crickets by use of poisoned baits. U. S. Dept. Agr. Leaflet 237, 6 pp., illus.
(60) Withrow, R. B., Biebel, J. P., and Eastwood, T. M.
1943. nutrient solution culture of greenhouse crops. Ind. Agr. Expt. Sta. Cir. 277, 27 pp., illus.
(61) Wolcott, G. N.
1933. an economic entomology of the west indies. 688 pp., illus. San Juan, P. R.

(62) Woodrow, G. M.
[n. d.] gardening in the tropics (eighth impression of "gardening in india"). 634 pp., illus. Paisley, England.
(63) Young, R. A.
1936. the dasheen, a southern root crop for home use and market. U. S. Dept. Agr. Farmers' Bul. 1396, 38 pp., illus.

ADDITIONAL REFERENCES

Anonymous.
1945. gollan's indian vegetable garden (winter season vegetables and summer season vegetables with gardening vocabulary in english and hindustani). Ed. 6, 106 pp. Calcutta, India.

———
1947. vegetables in the caribbean. Caribbean Comn. Crop. Inq. Ser. No. 5, 87 pp. Washington, D. C.
Alvarez García, L. A.
1943. cómo evitar y dominar las enfermedades de las hortalizas. Puerto Rico (Río Piedras) Agr. Expt. Sta. Cir. 108, 33 pp. Span. ed.
Anderson, E. M., Beckenbach, J. R., Eddins, A. H., McCubbin, E. N., Ruprecht, R. W., Jamison, F. S., and Minnum, E. C.
1944. commercial vegetable varieties for florida. Fla. Agr. Expt. Sta. Bul. 405, 30 pp., illus.
App, B. A.
1941. a report of some investigations on corn insects of puerto rico. Puerto Rico Univ. Jour. Agr. 25(4): 21–31.
Barrett, O. W.
1905. the yautías, or taniers, of porto rico. Puerto Rico (Mayagüez) Fed. Expt. Sta. Bul. 6, 27 pp., illus.
Beattie, W. R.
1942. the city home garden. U. S. Dept. Agr. Farmers' Bul. 1044 (rev.), 30 pp., illus.
Briggs, G.
1922. vegetable growing in guam. Guam Agr. Expt. Sta. Bul. 2, 60 pp., illus.

———
1926. effect of time of planting and fertilizers on the yield of vegetables. Guam Agr. Expt. Sta. Bul. 5, 27 pp.
Chung, H. L., and Ripperton, J. C.
1929. utilization and composition of oriental vegetables in hawaii. Hawaii Agr. Expt. Sta. Bul. 60, 64 pp., illus.
Cowles, H. T.
1936. el huerto y su cultivo. Puerto Rico (Río Piedras) Agr. Ext. Serv. Bul. 10, 85 pp. illus
Descartes, S. L., Díaz Pacheco, S., and Noguera, J. R.
1941. food consumption studies in puerto rico. Puerto Rico (Río Piedras) Agr. Expt. Sta. Bul. 59, 76 pp., illus.
Díaz Pacheco, S.
1940. la distribución de alimentos en la zona urbana de puerto rico. Puerto Rico (Río Piedras) Agr. Expt. Sta. Bul. 53, 17 pp.

———
1941. consumo de alimentos en la zona rural de puerto rico. Puerto Rico (Río Piedras) Agr. Expt. Sta. Bul. 57, 23 pp.
——— and Noguera, J. R.
1942. distribución de legumbres y hortalizas en las ciudades de río piedras y san juan. Puerto Rico (Río Piedras) Agr. Expt. Sta. Bul. 62, 40 pp.
Elayda, A.
1938. commercial raising of cabbage (brassica oleracea l.). Philippine Jour. Agr. 9(1): 103–118, illus.
——— and de Jesús, F.
1940. bermuda onion (allium cepa). Philippine Jour. Agr. 11(1–3): 301–327, illus.
——— Orgas, A. M., and de Jesús, F.
1936. the economic aspect of growing bermuda onion in the philippines. Philippine Jour. Agr. 7(3): 353–366.
Gilbert, W. W., Popenoe, C. H., and Caffrey, D. J.
1938. diseases and insects of garden vegetables. U. S. Dept. Agr. Farmers' Bul. 1371, 57 pp.

González Ríos, P., and Riollano, A.
1946. the improvement of native white beans (phaseolus vulgaris) by selection. Amer. Soc. Hort. Sci. Proc. 48: 425–436.
Greenwell, A. B. H.
1947. taro—with special reference to its culture and uses in hawaii. Econ. Bol. 1(3): 276–289.
Guam Agricultural Experiment Station.
1910–1932. annual reports [vegetable investigations].
Haddock, D.
1942. estudio de 96 granjas de la p.r.r.a. establecidas en cayey, cidra, y aibonito. Puerto Rico (Río Piedras) Agr. Expt. Sta. Bul. 63, 28 pp.
Harrison, Prof., and Bancroft, C. K.
1917. food plants of british guiana. Jour. Bd. Agr. Brit. Guiana 10(3–4): 143–177.
Hartep, L. L., and Zaumeyer, W. J.
1944. a monographic study of bean diseases and methods for their control. U. S. Dept. Agr. Tech. Bul. 868, 160 pp., illus.
Hawaii Agricultural Experiment Station [Honolulu].
1901–1947. [annual reports.]
Hill, E. B., and Noguera, J. R.
1940. the food supply of puerto rico. Puerto Rico (Río Piedras) Agr. Expt. Sta. Bul. 55, 32 pp.
Hoover, L. G.
1923. the chayote: its culture and uses. U. S. Dept. Agr. Cir. 286, 11 pp., illus.
Hutchings, C. D.
1940. vegetable breeding. Jamaica Agr. Soc. Jour. 44: 371–375.

———

1940. vegetable gardening. Jamaica Agr. Soc. 4-H Club Jour., 4 pp.
Jamison, F. S.
1946. the florida home garden. Fla. Univ. Agr. Ext. Bul. 131. 16 pp., illus.
Kinman, C. F.
1921. yam culture in porto rico. Puerto Rico (Mayagüez) Agr. Expt. Sta. Bul. 27, 22 pp., illus.
Leach, R., and Wright, J.
1930. collar and stem canker of pigeon pea (cajanus indicus), caused by a species of physalospora. Imp. Col. Trop. Agr. [Trinidad] Mem. 1, Mycol. Ser., 4 pp., illus.
Lind, H. Y., Bartow, M. L., and Miller, C. D.
1946. ways to use vegetables in hawaii. Hawaii Agr. Expt. Sta. Bul. 97, 110 pp.
Miller, C. D., Louis, L., and Yanazawa, K.
1946. food used by filipinos in hawaii. Hawaii Agr. Expt. Sta. Bul. 98, 80 pp., illus.
Molinary Salés, E.
1936. instrucciones prácticas sobpe el cultivo de la batata. Puerto Rico (Río Piedras) Agr. Ext. Serv. Bul. 8, 29 pp., illus.
Mullison, E. G., and Mullison, W. R.
1949. vegetable varieties in the tropics. Amer. Soc. Hort. Sci. Proc. 54: 452–458.
Nolla, J. A. B.
1929. the eggplant blight and fruit rot in puerto rico. Puerto Rico Univ. Jour. Agr. 13(2): 37–57, illus.
Ochse, J. J.
1931. vegetables of the dutch east indies. 1,006 pp., illus. Java.
Parris, G. K.
1938. the diseases of truck crops in hawaii. Hawaii Univ. Agr. Ext. Serv. Bul. 33, 79 pp., illus.
Parks, T. H., and Allison, C. C.
1944. the control of garden insects and diseases. Ohio State Univ. Agr. Ext. Bul. 76, 64 pp., illus. [Ed. 12]
[puerto rico] departamento de agricultura y comercio.
1944. almanaque agrícola de puerto rico para el año 1944. Ed. por J. Bagué. 432 pp., illus. San Juan, P. R.

REVISTA DE AGRICULTURA DE PUERTO RICO, DEPARTMENT OF AGRICULTURE AND COMMERCE, GOVERNMENT OF PUERTO RICO, SAN JUAN.
1937–45. [VEGETABLE CULTURE.] 1937, No. 1, pp. 90–95; No. 2, pp. 368–377, 378–381; No. 3, pp. 480–490; No. 4, pp. 783–786; 1938, No. 4, pp. 577–607; 1939, No. 4, pp. 547–548; 1941, No. 1, pp. 47–49; 1942, No. 1, pp. 45–47; No. 2, pp. 222–225; 1945, No. 1, pp. 23–24.

RIOLLANO, A.
1942. THE VALUE OF FILTER PRESS CAKE AS A FERTILIZEP FOR VEGETABLE CROPS. Puerto Rico Univ. Jour. Agr. 26(4): 99–104. *Also in* Amer. Soc. Hort. Sci. Proc. 42: 547–550. 1943.

——— ADSUAR, J., and RODRÍGUEZ, A.
1948. BREEDING PEPPERS RESISTANT TO A PUERTO RICAN TYPE OF MOSAIC. Amer. Soc. Hort. Sci. Proc. 51: 415–416.

——— and RODRÍGUEZ, J. P.
1944. TRIALS WITH SOYBEANS. Amer. Soc. Hort. Sci. Proc. 44: 441–444.

——— WARMKE, H. E., and ALVAREZ, L. A.
1947. INTRODUCING AND BREEDING NEW TOMATO VARIETIES FOR PUERTO RICO. U. S. Reg. Veg. Breeding Lab., Charleston, S. C. [Processed.]

RODRIGO, P. A.
1939. FURTHER ACCLIMATIZATION STUDIES ON CAULIFLOWER. Philippine Jour. Agr. 10(4): 403–404.

——— and URBANES, P. S.
1937. TRIAL PLANTINGS OF IRISH POTATO. Philippine Jour. Agr. 8(2): 147–160, illus.

——— URBANES, P. S., and OLAN, V. R.
1936. PRELIMINARY STUDIES ON THE FLOWERING AND SEEDING OF ONIONS IN THE PHILIPPINES.—I. Philippine Jour. Agr. 7(1): 1–20, illus.

——— URBANES, P. S., and OLAN, V. R.
1938. VARIETY TESTS OF CABBAGE. Philippine Jour. Agr. 9(1): 1–30, illus.

ROQUE, A., and ADSUAR, J.
1941. STUDIES ON THE MOSAIC OF PEPPERS (CAPSICUM FRUTESCENS) IN PUERTO RICO. Puerto Rico Univ. Jour. Agr. 25(4): 40–50, illus.

SMITH, F. B., and THORNTON, G. D.
1944. COMPOSTING AND MULCHING. Fla. Agr. Expt. Sta. Press Bul. 602, 4 pp., illus.

SPENCER, A. P.
1937. FLORIDA VEGETABLES. Fla. Agr. Ext. Serv. Bul. 90, 67 pp., illus.

STAHL, A. L., and VAUGHAN, P. J.
1942. PLIOFILM IN THE PRESERVATION OF FLORIDA FRUITS AND VEGETABLES. Fla. Agr. Ext. Serv. Bul. 369, 92 pp., illus.

SUPERINTENDENT OF DOCUMENTS, U. S. GOVERNMENT PRINTING OFFICE, WASHINGTON 25, D. C.
A price list entitled "Plants," is available free. The publications listed thereon are available for a few cents each.

THOMPSON, J. B.
1925. PRODUCTION OF SWEETPOTATO SEEDLINGS AT THE VIRGIN ISLANDS AGRICULTURAL EXPERIMENT STATION. Virgin Islands (St. Croix) Agr. Expt. Sta. Bul. 5, 14 pp., illus.

TUCKER, C. M.
1927. PIGEON PEA ANTHRACNOSE. Jour. Agr. Res. 34: 589-596, illus.

VIRGIN ISLANDS AGRICULTURAL EXPERIMENT STATION.
1902–1932. REPORTS [VEGETABLES]. 1902, pp. 4–9; 1923, pp. 7–10; 1924, pp. 9–12; 1925, pp. 6–10; 1926, pp. 4–9; 1927, pp. 4–7; 1928, pp. 6–8; 1929, pp. 6–9; 1930, pp. 7–8; 1931, p. 11; 1932, pp. 12–13.

WATSON, J. R., and TISSOT, A. N.
1942. INSECTS AND OTHER PESTS OF FLORIDA VEGETABLES. Fla. Agr. Expt. Sta. Bul. 370, 118 pp., illus.

WILLIAMS, R. O., and WILLIAMS, JR., R. O.
1941. USEFUL AND ORNAMENTAL PLANTS IN TRINIDAD AND TOBAGO. Ed. 3, rev. 265 pp. Trinidad and Tobago.

WOLCOTT, G. N.
1941. THE ESTABLISHMENT IN PUERTO RICO OF LARRA AMERICANA SAUSSURE. Jour. Econ. Ent. 34: 53–56.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1950—887272